Illuminating Engineer

XXVII. October, 1934 Price 9

THE JOURNAL OF GOOD LIGHTING

1934

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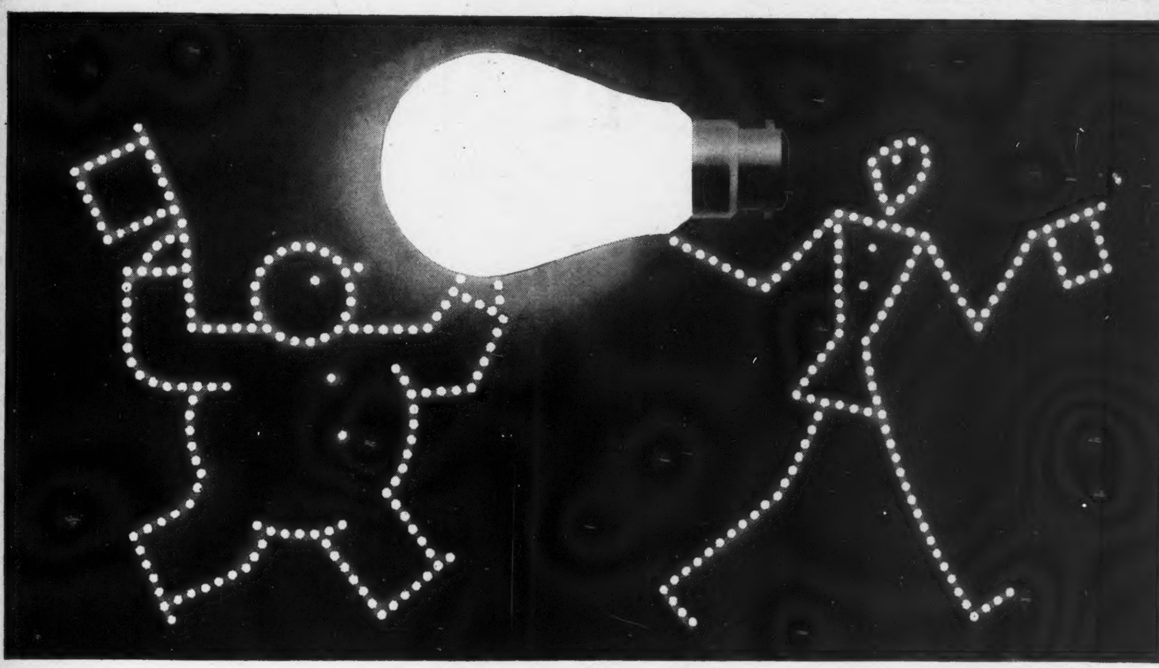

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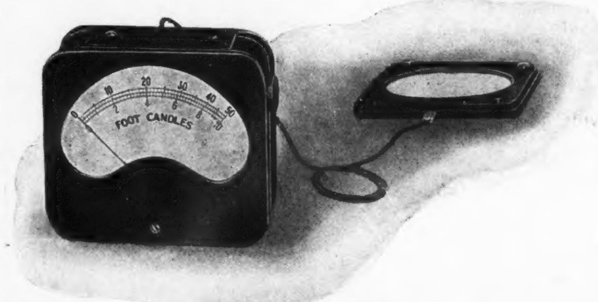

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Official Journal of
THE ILLUMINATING ENGINEERING SOCIETY
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INCORPORATED 1930

The ILLUMINATING ENGINEER

THE JOURNAL OF GOOD LIGHTING

Edited by

J. STEWART DOW

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Principal Contents:

Come, Let Us Reason Together . . .

DURING the past month much learning has come to Aberdeen. The thousands who assembled for the meeting of the British Association were followed by the hundreds who attended the Eleventh Annual Meeting and Conference of the Association of Public Lighting Engineers.

To this came public lighting engineers and Chairmen of Lighting Committees from all parts of the United Kingdom. It is the one occasion during the year when knowledge can be brushed up, old ties renewed, old arguments resumed. Not only in the lecture theatre is information conveyed. Much help comes from casual chats in the hotel or on excursions. Business and pleasure combined. So it is at all good conferences.

The Association lists 170 members and junior members. Yet in the Gas Journal Directory there is a list of about 300 public lighting superintendents, and a further list of about 3,000 places where a gas supply is available. In very many of these there will also be an electric supply. Anyway, *some* street lighting must exist and there must be *somebody* to look after it.

Why ever don't they come and share in the good things?

Illuminating Engineering Society

Provisional Programme for Session 1934-35

In what follows we give particulars of the Provisional Programme of the Illuminating Engineering Society for the forthcoming Session. Except in the case of the Opening Meeting (October 9), meetings will commence at 7 p.m. and will be preceded by light refreshments at 6.30 p.m.

1934.

Oct. 9 (6.0 p.m.).—The OPENING MEETING, when the PRESIDENTIAL ADDRESS will be delivered by Mr. H. Hepworth Thompson, the REPORT OF PROGRESS will be presented and various EXHIBITS illustrating Progress in Illumination will be on view. (To be held at the E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, London, W.C.2.)

Nov. 13.—A Paper will be read by Mr. R. W. Daniel (H.M. Inspector of Factories, Sheffield), dealing with INDUSTRIAL LIGHTING: SOME PROBLEMS IN SHEFFIELD AND THEIR SOLUTION. (To be held at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1.)

Dec. 11.—A Paper will be read by Mr. H. E. Bloor (Engineer and Manager of the York Gas Company) on FLOOD LIGHTING BY GAS. (To be held at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1.)

1935.

Jan. 8.—A Paper on STAGE LIGHTING will be read by Mr. L. G. Applebee.

Feb. 5.—The ANNUAL DINNER will take place at the Trocadero Restaurant, Piccadilly, London, W.1 (7 for 7.30 p.m.).

Feb. 19.—A Paper will be presented by Mr. J. M. Waldram and Mr. J. M. Sandford entitled, THE TIME CHARACTERISTICS OF TUNGSTEN FILAMENT LAMPS FOR FLASHING SIGNALS, SIGNS AND BEACONS.

March 12; April 9; May 7.—For these two dates and for May 7, when the Annual General Meeting will take place, the following topics, amongst others, have been suggested. Electric Discharge Lamps; Thermal Tests of Illuminating Glassware; Engineering Aspects of Architectural Lighting; A Photo-electric Method for the Photometry of Gas Discharge Lamps; Simple Systems for Recording and Displaying Measurements of Illumination.

Supplementary meetings, at which exhibits illustrating progress in illumination will also be shown, have been arranged to take place in Birmingham (October 11) and Liverpool (October 16). Any members who are prepared to exhibit novel and interesting apparatus at such meetings are requested to communicate with the Hon. Secretary (Mr. J. S. Dow, 32, Victoria-street, London, S.W.1.).

Illuminating Engineering Society, U.S.A.

28th Annual Convention.

The programme of the above Convention, which opened in Baltimore, U.S.A., on October 1, includes about thirty addresses, papers and reports, arranged in parallel sessions devoted to sets of papers on kindred subjects, such as electric discharge lamps, photometry and radiation, "built-in" fittings, and illuminating glassware. An interesting feature is the display of lighting equipment, analogous to the exhibition arranged biennially by the Association of Public Lighting Engineers, and the annual display at the opening meeting of the Illuminating Engineering Society in this country, but no doubt of a more elaborate nature. Another item of news is the formation of a "Better Light—Better Sight Bureau." This motto is to be incorporated in the Society's badge.

Highway Lighting Researches.

Enterprising demonstrations and researches on highway lighting, which have been proceeding in New Jersey, U.S.A., for some years, are mentioned in the Transactions of the Illuminating Engineering Society, U.S.A. (Vol. XXIX., Sept., 1934). In 1933 ten lighting demonstrations were planned. Two of these have been in operation for some time, and a new installation, comprising ten sodium lamps, is being added. The inquiry not only includes tests of trial lighting installations but also investigates into the relation between lighting and street-safety. Commissioner Hoffmann of New Jersey has stated that 46 per cent. of all accidents and 65 per cent. of fatal accidents on the State highways occurred after night fall—surely a large and significant proportion! The Commissioner also expresses the opinion that "accidents at night occur four times more frequently by motor vehicles than in daylight." Commissioner Harnett, of New York, reports similar experience and expresses the belief that adequate lighting would prevent at least one quarter of the motor vehicle accidents which occur at night.

THE ASSOCIATION OF PUBLIC LIGHTING ENGINEERS

The Association is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Eleventh Annual Meeting and Conference Held in Aberdeen, Sept. 17th—20th, 1934

—oOo—

THE eleventh annual meeting and conference of the Association of Public Lighting Engineers, held in Aberdeen during September 17—20, was a most successful gathering. There were over 300 names on the list of members, friends, and delegates—a very satisfactory muster for such a distant spot.

On the opening evening there was a reception at the Art Gallery by the Lord Provost, magistrates, and Council of Aberdeen, and the conference was officially opened at the Music Hall Buildings on the following morning. The induction of the new President (Mr. Alexander Forbes, of Aberdeen) was followed by a paper by Mr. J. M. Ward and Mr. J. Mann, entitled, "Lighting Department Practice and Equipment." In the afternoon, after a short demonstration illustrating Street-lighting Calculations, by Mr. W. J. Davey, the Hon. Secretary gave a brief account of the Indoor Exhibition (in which eighteen firms participated). Members and delegates then adjourned to the exhibition, which proved to be a very interesting one.

ALEXANDER FORBES (Aberdeen).
(President of the Association of Public Lighting Engineers, 1934-1935.)

The evening was devoted to the Association supper and dance, which was held at the Beach Dance Hall, one of the best in the country. Here a very agreeable evening was passed; no doubt this feature, the first of its kind arranged by the Association, will again figure in future programmes.

The second day of the conference was, as usual, devoted to the annual general meeting (see p. 304) and to the reading of further papers, which included "The Technical Aspect of Recently Developed Street-Lighting Fittings" (Dr. S. English), "The Design and Application of Traffic Signs" (C. H. Woodward), "Road Surface Reflection Characteristics and their Influence on Street Lighting" (J. M. Waldram), and "A New Lighting-Up Table based on Illumination Requirements" (G. H. Wilson). On this day members and delegates were entertained to luncheon by the Corporation Gas and Electricity Departments at the Town and County Hall, whilst in the evening an opportunity was afforded of inspecting the special street-lighting and floodlighting installed for the occasion. (See appendix to the Presidential address, p. 284.) The concluding item, on Thursday, September 20, took the form of a motor-coach excursion through the magnificent scenery adjacent to Aberdeen. A delightful and unrehearsed item occurred at Linn o' Dee, where the party had the privilege of getting a glimpse of H.M. the Queen who, accompanied by H.R.H. Prince George and Princess Marina, was paying a visit to the famous falls.

It was a rare experience for the Association to assemble in a city at once so far north and so interesting as Aberdeen, whose picturesque granite buildings lie between two rivers, the Don and the Dee. This opportunity should be taken to acknowledge gratefully the generous hospitality which the conference enjoyed, and to record the extraordinary pains taken by the President, Mr. Alex. Forbes, in preparing for the visit. When it is recalled that on this occasion there was both an indoor and an outdoor exhibition to be supervised, and that almost all details had to be settled by correspondence, it can be seen that his task was a very considerable one.

Others to whom thanks are due are Mr. E. J. Stewart, the hon. Editor, for the preparation of a very useful and comprehensive annual report; Mr. E. Stroud, the chairman of the Exhibition Committee; and Mr. W. J. Jones, of the E.L.M.A. Lighting Service Bureau, who kindly arranged for the installation of up-to-date lighting in the lecture theatre during the period of the conference.

Presidential Address

by

ALEXANDER FORBES

(Inspector of Lighting, Aberdeen)

Delivered at the Eleventh Annual Meeting and Conference of the Association of Public Lighting Engineers, held in Aberdeen during September 17th to 20th, 1934

Gentlemen,

My first words must be to thank you for the honour you have conferred on me in electing me to be your President, and on my native city, in making it the scene of this year's Conference.

In accepting this important post, I realise that I have something to live up to, having regard to the distinguished reputation my predecessors have earned in the Public Lighting Services. It will be my earnest endeavour to do everything in my power to further the many interests of our Association during my year of office.

I am pleased to note that so many lighting engineers, along with their Chairmen, and, in many cases, other members—of their Committee, have travelled so far North to attend this Conference, and also to view our city. I trust their first impression of our beautiful granite buildings will be a lasting one.

A president, in framing his address, may pursue either of two courses—he may survey the general trend of progress, or he may select some aspect of his subject with which he is specially familiar. I propose to combine these two methods. My Council have asked me to include in my address particulars of the lighting of our city, in accordance with the understanding reached at a previous Conference that the lighting engineer of each town or city visited should present some record of the lighting in his charge.

But, before doing so, I would like to comment briefly on a few technical points and general topics which are of special interest to our Association at the present moment.

ELECTRIC DISCHARGE LAMPS.

The excellent Exhibition which has been assembled for the information of members and delegates should in itself serve as a valuable record of technical progress. I need only mention one or two developments of outstanding importance. We are, for example, all keenly interested in the new electric discharge lamps. Our country has, I understand, been well forward in this field. Discharge lamps, which proved an outstanding novelty at our Conference last year, have already become familiar in many cities. The substantial increase in efficiency (approximately two and a half times that of the incandescent lamps of similar consumption) will no doubt lead to their extended use, especially if, as we may hope, lamps of smaller consumption become generally available. Some progress also has been made towards improvement of the unusual colour of the light, and a further improvement in this respect would be welcome, even if some sacrifice in efficiency is involved. Equally interesting are the modifications in the design of lanterns which the use of these new lamps has occasioned, and which are to be discussed in one of the papers delivered at the present Conference.

"DIRECTIONAL" LIGHTING.

Another tendency, well illustrated at the Exhibition, is the use of "directional" reflectors intended primarily to improve the mid-span illumination, but also, in the wider sense in which Lt. Comm. Haydn T. Harrison has used the term, to increase illumination at any other special points. The problem how far to use these directional methods, and how far to utilise general diffused lighting, is one that with which public lighting engineers are continually preoccupied. It is sometimes forgotten that other considerations besides the needs of motor traffic—important as they are—apply to the main thoroughfares of important cities, and that, even on arterial roads, "appearance" can rarely be ignored. It is for this reason that one learns with interest, tempered by some degree of scepticism, of efforts abroad to solve the problem by the aid of fixed headlights, mounted below eye-level, and trained in the direction of the traffic, thus giving conditions free from glare, but open to possible objection in other respects.

EFFECT OF SURROUNDINGS.

Glare is another problem that is always with us. Its definition presents considerable difficulties, as the framers of the British Standard Specification have found. One point I would like to emphasise—the very important part played by surroundings. A lighting unit that appears decidedly glaring on a dark country road may lose its offensiveness when there is a light-coloured building as its background, and may appear to exhibit merely a mild sparkle when seen in the vicinity of illuminated signs and brightly-lighted show-windows.

Surroundings, whilst unfortunately not under the control of the public lighting engineer, may have a vast influence upon the results of his work. The value of light-coloured buildings in facilitating diffusion of light, diminishing contrast, and softening shadow, has already been mentioned. I think you will agree that Aberdeen is fortunate in its clean grey streets, which is a joy to behold when a night of rain has been followed by a period of sunshine which dries the surface, giving the impression that cleaning on a lavish scale has been carried out during the night! The buildings are practically all constructed of the native Rubislaw or Kemnay granite, which assists our street lighting to a marked degree.

The influence on public lighting of the road surface—which is to form the subject of a paper at this Conference—is of even greater importance. The dark polished surfaces now usual in cities give little aid to the lighting engineer, and have, indeed, caused him to reconsider his technique, relying more on the reflected image of the light sources than the actual illumination of the roadway. The hard granite setts in our streets have an advantage in this respect. Their chief drawback, the noise made by rattling iron-ringed wheels, has been the subject of complaint in the past, but becomes continually less as the use of pneumatic tyres on all forms of vehicles increases.

THE ROAD TRAFFIC BILL.

Before concluding this initial survey I may refer to several recent events of outstanding importance to the public lighting engineer. The Road Traffic Bill, defining a built-up area as one in which a system of street-lighting is maintained out of the rates and imposing a speed limit in such areas, has been the subject of much comment. Efforts have been made to convey to the authorities the views of those interested in lighting, and the modifications of the Bill since adopted go far towards mitigating the objections originally felt. Reflection seems to have

led to the conclusion that the Bill is not likely to act prejudicially to the development of public lighting, even though in principle the association of a speed limit with the existence of public lighting seems illogical, and the administration of the Act may present difficulties.

We must, however, appreciate the seriousness of the position as revealed by the Ministry of Transport Report on Fatal Road Accidents in Great Britain for 1933—a total of 7,202 killed and 216,328 injured. Consideration of these figures should incline one to whatever sacrifice is involved in diminished speeds. For after all, the speed of motion is the fundamental cause of hazard; such excuses as claims of drivers that they were "puzzled by street lamps" or "dazzled by motor-car lights" surely do not exonerate them from blame for attempting to maintain speed in such circumstances.

Nevertheless, it is, of course, our bounden duty to do everything possible to eliminate such defects, which are in fact often occasioned by the extreme economy with which public lighting is administered. It is exceedingly difficult to obtain accurate statistics illustrating the practical benefits of good public lighting, but such analysis as has been attempted seems to lead to two conclusions: (1) the proportion of accidents occurring by night has tended to increase steadily during recent years (a natural result of the increasing use to which roads are put during hours of darkness), and (2) taking all the relevant circumstances into account, it is evident that the security of traffic during darkness must be very much less than in full daylight.

The continual growth in the speed and volume of motor traffic obviously demands much better street-lighting than in the past. Yet, in fact, public lighting engineers are expected to avoid any increase in their estimate, and it is thus only by using their professional skill and by taking advantage of the more efficient lamps and appliances introduced by manufacturers that improvements in lighting conditions can be made. If local authorities would agree to grant an increase of, say, 50 per cent. on the year's estimate on electric current and consumpt of gas, what a valuable increase in the illumination of our streets—an advance which would undoubtedly benefit the city in a business sense—could be made!

DEPARTMENTAL COMMITTEE ON PUBLIC LIGHTING.

The second event to which reference should be made is the appointment by the Ministry of Transport of a Departmental Committee "to examine and report what steps could be taken for securing more efficient and uniform street-lighting, with particular reference to the convenience and safety of traffic."

I learn with pleasure that Mr. H. F. Gillbe, the Secretary of the Committee, has accepted our invitation to be present as the guest of the Association, and that other members of the Committee, which is of a very representative character, will be with us. The appointment of this Committee is an indication of a recognition by the Ministry of the importance of public lighting in relation to traffic. The wide terms of reference should enable it to survey the whole position fully and to take advantage of all suggestions that may be offered by this Association and others, for the advance ment of public lighting.

PUBLIC LIGHTING IN ABERDEEN.

Let me now pass on to the second object of this address, namely, to describe some of the chief features of our lighting in Aberdeen.

I should explain, in the first place, that both our Gas and Electricity Departments are owned by the Corporation. Accordingly when lighting schemes have to be reported on, it is somewhat difficult to decide what illuminant should be adopted, as the present rates of gas—2s. per 1,000 C.F. up to 43,000,000. and all over this amount 1s. 3d. per 1,000 C.F., and for electric current—2d. per unit for the first 230,000, 1d. per unit for the next 270,000, and ½d. for all consumpt over 500,000 units—are fairly keen, and work out pretty much on a par for price per C.P. and maintenance. Generally the argument settles itself by giving each Department equal shares of lighting. Our total consumpt of gas for the year 1933-34 was 52,896,700 cubic feet, and for electricity 598,575 units.

I was appointed Inspector of Lighting in September, 1913, and for the winter of 1914-15, I had definite ideas of improved lighting being carried out, but the outbreak of war in August closed the door on all my schemes, and public lighting in our geographical position on the sea coast, was practically a negative term. As an example, it is interesting to mention that in February, 1916, we had eleven 20-watt and fourteen 30-watt electric "metal filament" lamps, and 66 rat-tailed gas burners consuming 1¾ cubic feet of gas per hour. This proved to be our lowest number of lighting points, and certainly the poorest candle power during the war period. These were anxious days for all of us, and many were the complaints uttered at such reductions of lighting. The Press—in a jocular vein—on one occasion dubbed me "The Prince of Darkness."

ELECTRIC LIGHTING.

After the war finished, all our electric arc lamps were scrapped, as with the advent of the gas-filled lamp, new and efficient lanterns were introduced for street lighting, at a much lower maintenance cost. Series wiring is more or less still functioning, but when more prosperous times appear, parallel wiring will be introduced, thus obtaining the advantage of more up-to-date apparatus.

The principal thoroughfares of our City are lighted by electric lamps, chiefly in sections on series wiring, nine lamps in a circuit on the 440 volt, and four on the 220 volt main cables. One great advantage in series burning is the extraordinary long life of the 55 and 50 volt lamps. The great bulk of our electric cables are on the D.C. and this at the moment is of no use for the latest type of electric discharge lamps, but this problem is being, or will be, successfully overcome by the manufacturers.

Recently, I had the whole of our electric lanterns (36) renewed along Union Street (our main principal street) and these had to be specially made to function on "series wiring" provided with the latest type of asymmetric refractors, set to 160° fitted inside a dust-proof pear-shaped outer globe, 750-watt 50 volt lamps being used, and on testing for C.P. with a Holophane Lumeter, I obtained a maximum reading of 2.5 candles, and a minimum of 0.21 candles, which is very good for a street 88 feet wide (including pavements), spacing distance—measured along the centre of street—130 feet, and height of light source fully 22 feet. These lamps may possibly be considered unduly bright, but we find that, with this mounting height, motorists do not complain of "glare," and general satisfaction has been expressed on all hands on the greatly improved lighting.

Reference has already been made to the electric discharge lamps for which special lanterns have been designed. It will be interesting to note what improvements have been made on these lanterns at the demonstrations of street lighting during our Conference week in Union Street, Union Terrace and King Street, and I would suggest that all our members should make a point of inspecting these units.

GAS LIGHTING.

Bus routes have been engaging our attention during these past years, and five-light No. 2 mantle high-power low-pressure gas lamps, fitted with untarnishable steel directional reflectors, have been installed, and in the narrower roadways are giving excellent results. We have just completed a main bus route over a mile in length, with similar lighting, each lantern being equipped with an automatic clockwork con-

troller, and, as an experiment, we adopted a gas "Reservoir" steel pole with cast iron base to improve the appearance of the pillar. By this method, no M.I. gas pipe is required. The average spacing is 114 feet, and the amounting height 15 ft. 9 in. Tests revealed a maximum of 2.00 foot-candles, and a value of 0.075 foot-candles for mid-span readings.

Automatic controllers for gas lighting have been installed in our outlying housing districts, and are giving good results, two full rounds being lighted by this method. The same applies to where the smaller sized electric lamp sections are erected, "time switches" being fitted. One section of electric lamps is controlled by means of the Radiovisor Light Sensitive Bridge, and, with the exception of a minor fault, has functioned excellently.

AUTOMATIC CONTROL.

Regarding automatic control, I am satisfied that this system of lighting can be carried out at less cost than by hand torch lighting, but, at the same time, I hold strong views that more efficient results are obtained by the latter system, as the man has to visit the lamp twice a day, and if the mantles are not giving maximum results at either "lighting" or "extinguishing" time, then it is up to him to make good the defect right away. In automatic lighting, the attendant merely has a glance along the streets to see if all his lamps are burning, but he cannot pick out lamps which require adjustments. It is sufficient for him to know that the lamps are all alight.

For many years our Department has used no hard gas mantles, as I have proved that the soft silk mantles, if properly used, give better results than the former, and certainly are much cheaper. We take mantle averages (September to April) and this works out, over a seven-month period, at 2.063 mantles per nozzle. The secret of this low consumpt lies in the "burning off" of the mantle. This must not be done when the men are attending to their round in the forenoon, but left until "lighting up" time, when the mantle is "burned off," allowed to cool, then relit, when the mantle takes its proper shape and left burning until "extinguishing" time. The fabric of the mantle has then been allowed sufficient time to "harden off" and will continue to function for months, even years. These mantles assume the same shape as does the inner cone of the Bunsen flame of the burner, and better results are obtained due to this fact.

The spacing distance of all our lamps averages 36 yards.

MAINTENANCE.

All gas lamps or lanterns are cleaned every week, and electric lamps and reflectors every four weeks. This is a most important point, as clean glass and reflectors count for much better illumination, and dirty glass should not be tolerated under any circumstances. All our lamp pillars and lanterns, both gas and electric, are painted every second year during the summer months by our own men, thus keeping our equipment in good order and appearance. We are indebted to the Police Authorities for reporting failures in lighting, and also damages to lamps, to certain men in our Department at their home address, after ordinary working hours; and as these men have cycles, reports are attended to at once.

For "lighting up" and "extinguishing" of lamps, both gas and electric, our men proceed direct from their own homes, and I contend that this system is efficient, as there is little object in men having to meet at certain depots to receive instructions as to "when to proceed," etc. Our men meet at workshops every Monday morning for instructions, and an average time is given out for the week for "lighting" and "extinguishing." It is left to the men to commence according to the nature of the night and morning. and correct returns are entered on time-sheets. I am fully conscious that this idea would not work out in large cities, such as London, Glasgow, etc., but this system, I am confident, should be applied to all undertakings of the size of Aberdeen, as one gets a squad of men who can be thoroughly depended on to carry out the tasks allotted to them, keeping in mind that they never know when the supervisor may be on their heels. In my twenty-one years' experience, once only has a man failed to turn out at lighting time.

Traffic Control does not come within the scope of our Department, but is under the Police. There are but seven junctions fitted with the automatic coloured signals in our city, nine "Keep Left," two "No Through Traffic," and five "Caution" signal pillars, but it would be advantageous to have more of these safety devices fitted up at important busy junctions.

STAFF.

The staff of the Department is as follows:—

Inspector of Lighting	1
Typist	1
Foreman (Gas)	1
Sub-foreman	1
Lamp fitters	2
Electrician	1
Electric lamp attendants	2
Storeman	1
Tinsmith	1
Lamplighters	42
Total	53

The foreman is provided with motor-cycle and sidecar for visiting men throughout the day hours, and for the inspection of lighting, he patrols, on foot, alternative districts after "lighting up" times.

GAS LAMPS.

Low-pressure burners. Inverted.						High-power low-pressure lamps. Light.				
1	2	3	4	6	Total	1	3	5	8	Total
4,105	52	27	357	2	4,543	52	14	137	2	205

ELECTRIC GAS-FILLED LAMPS.

Watts.									
60	75	100	150	200	300	500	750	1,000	Total
308	77	83	139	249	136	84	36	3	1,115

AUTOMATIC CLOCK CONTROLLERS.

To light and extinguish gas lamps	728
To extinguish only	1,271
Total	1,999
Electric lamp time switches	48
Light Sensitive Bridge	1
Total	49

Our public lighting extends to 147 miles of streets, 24½ miles of which are electric lamps, the main thoroughfares being lighted by electric lamps ranging in size from 1,000 watt to 150 watt lamps. A few 'bus routes have 3 to 8-light low-pressure gas lamps, but at present the great majority of our streets are lighted by means of one-light gas lanterns (square), plus a few hundreds of the old round bowl type. High-power low-pressure gas lamps with pear-shaped globes instead of the square lanterns, are a great improvement as regards illumination, as no shadows are cast from this class of fitting, and they compare more favourably with the smaller type of electric fittings, such as those utilising 60, 75, or 100 watt lamps.

During the month of August, estimates are brought before our Committee for the year's lighting. As is customary with other lighting engineers, one has to press for as large a sum as possible to improve city lighting, but in these days of financial stress it is diffi-

cult to obtain what one would desire. For the season, 1933-34, our lighting estimate was fixed at £21,235, which represents a sum of barely 2s. 6½d. per head per annum, or fully ½d. per head per week; or, put another way, is equal to a rate of 3.62d. in the £, and although the £21,000 looks a large sum, it must be admitted a very moderate sum indeed, when each individual in our city has only to pay 2s. 6½d. for a whole year's lighting—in other words, the bare cost of an ordinary concert ticket or three ounces of tobacco!

I have already emphasised the vital importance of good public lighting in these days of rapid and dense motor traffic, and have pointed out that greater generosity in this direction would often prove a good investment and would be justified by business considerations, besides humanitarian ones. The influence of improved public lighting in attracting visitors and stimulating business has, I believe, been proved by experiments conducted abroad.

In the meantime we, as public lighting engineers, have necessarily to adopt "efficiency with economy" as our motto. If economy must be exercised it becomes all the more incumbent upon us to keep ourselves informed of the latest advances and to be vigilant in studying their application, so that such funds as are allotted may be expended to the best possible advantage, and so that, not only the important streets of our towns and cities, but also the poorer districts may receive lighting that is at least moderately adequate.

Before closing this address, therefore, I would take the opportunity of expressing the Association's thanks to the many firms who have so obligingly exhibited their goods at the indoor exhibition, and for the excellent collection of electric lighting units (both of the discharge and filament types) and also the splendid display of high-power low-pressure gas lamps fitted up on steel and concrete pillars, which have been erected in our principal streets to show, not only our own members and delegates, but also the public of Aberdeen, the very latest types of street-lighting apparatus.

In this connection, I thank both the local Gas and Electricity Departments and my staff for the excellent service they have given me at this time.

APPENDIX

Summary of Outdoor Lighting Exhibits

(Based on information furnished by the manufacturers of the lamps and lighting equipment exhibited)

X=Total breadth of street, including pavements.

Y=Average spacing of lamps—measured up centre of street.

Z=Average mounting height to light source.

A.—STREET LIGHTING

1. Albyn Place.

The General Electric Co.—Asymmetric street lighting, "Clubfoot" fittings. These lamps were erected along this main tram-car route last season, and are popular with motorists especially as visibility is good, with little or no glare from the 200-watt lamps.

(X=43 ft. 6 in. Y=110 ft. Z=19 ft. 6 in.)

2. Union Street.

Siemens Electric Lamps and Supplies, Ltd.—Four D.A.4 lanterns, which, it is claimed, have features that enable it to be adapted for almost any conditions of service. The lighting unit consists of a cast-iron suspension piece, to which is bolted a one-piece spun copper dome and 26½-in. reflector of heavy gauge. Below this is suspended a box-shaped lantern hinged at one side, so that it can be fully opened for cleaning, lamp replacement, etc. The lantern is glazed with hammered glass on the sides and flashed opal at bottom. Inside the lantern is a patented two-way reflector system, giving control of the light output in both the vertical and horizontal planes. The overall depth of the lantern is approximately 18½ inches, and its weight is approximately 50 lb.

The D.A.5 lantern, which is situated midway between the above D.A.4 lanterns, is suitable for promenade and all open-space lighting, the glassware being known as ripple opalescent. No shadow is cast by the bottom copper spinning.

(X=82 ft. Y=125 ft. Z=23 ft.)

3. Union Street.

Holophane, Ltd.—Five special bowl-type prismatic refractors, with circular lanterns, No. 564, for use with electric discharge lamps. These lanterns are equipped with 400-watt "Escura" lamps. The positions in Union Street are near the Music Hall Buildings (Conference Rooms), and this is the initial appearance of these new Holophane E.D. Refractor Lanterns.

(X=88 ft. Y=128 ft. Z=23 ft.)

4. Union Street.

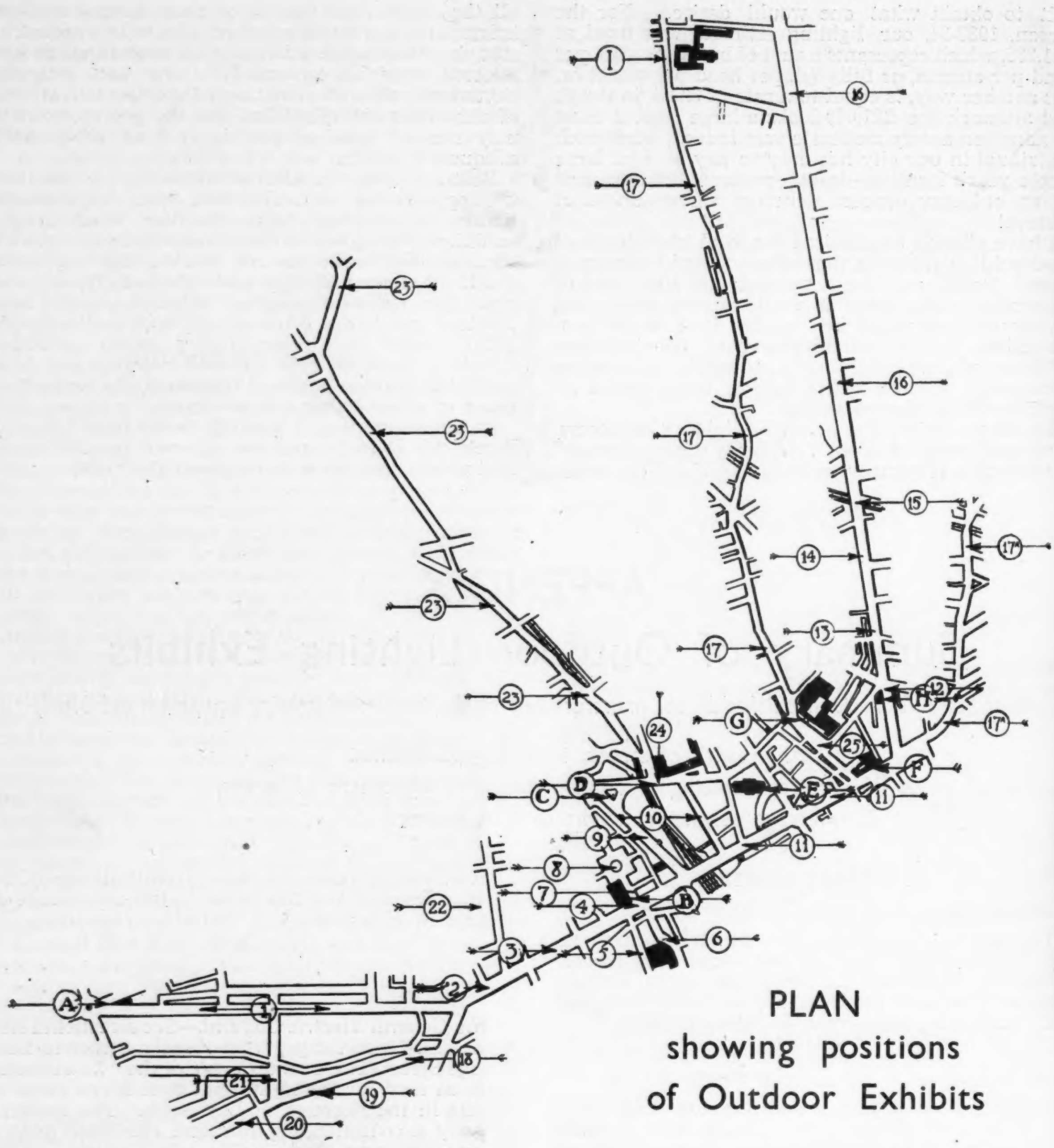
The General Electric Co., Ltd.—Six directional lanterns and Osira lamps, from Huntly Street to near Bridge Street. These lanterns are of the "Lewisham" type, as used for the lighting of over seven miles of streets in the Borough of Lewisham. The lanterns embody a concentrating refractor combined with a special diffusing glass. The candle-power in the direction of traffic flow is about 6,000 candles, but is reduced in the reversed direction to about 3,000 candles to obviate glare towards oncoming traffic. The lanterns are mounted at a height of about 23 ft. on existing pillars. The recommended height is 25 ft.

At the junctions of Bridge Street and Union Terrace three dispersive lanterns and Osira lamps, suitable for the lighting of road junctions, are fitted up. These lanterns consist of the standard 300—500-watt "Wembley" lantern body, fitted with a special low-absorption three-ply flashed white opal globe of modern design. Features are the good diffusion and absence of glare; recommended for intersection lighting where a "dead cut-off" type of lantern is unsuitable.

(X=88 ft. Y=120 ft. Z=23 ft.)

5. Dee Street (Opposite Music Hall).

Holophane, Ltd.—Four Duo-Dome refractor lanterns, No. 519/22/4611, equipped with 500-watt regular type gas-filled lamps. These lanterns are centrally suspended, so that the type of dome refractor used gives a two-way 180° light-distribution. This new



PLAN
showing positions
of Outdoor Exhibits

A.—STREET LIGHTING

1. Albyn Place.
2, 3, 4 and 11. Union Street—principal main street.
5. Dee Street.
6. Crown Street.
7. South Silver Street.
8. Golden Square.
9. Union Terrace.
10. Belmont Street.
12, 13, 14, 15 and 16. King Street.
17. Gallowgate to College Bounds.
17A. Justice Street—Park Street.
18, 19 and 20. Union Grove.
21. Albyn Grove.
22. Rubislaw Terrace.
23. Woolmanhill to Berryden Road.
24. Schoolhill.
25. Broad Street.

B.—FLOODLIGHTING

A. Albyn Place
B. Music Hall, Union Street (Conference Rooms).
C. Union Terrace (Hotel Headquarters).
D. Schoolhill (Art Gallery).
E. Union Street.
F. Union Street.
G. Broad Street (Marischa College).
H. King Street.
I. College Bounds.

series of duo-dome refractor lanterns are the latest development in prismatic dome types. They are stated to have many new features of interest that make for higher efficiency and easy maintenance.

(X=42 ft. Y=120 ft. Z=24 ft.)

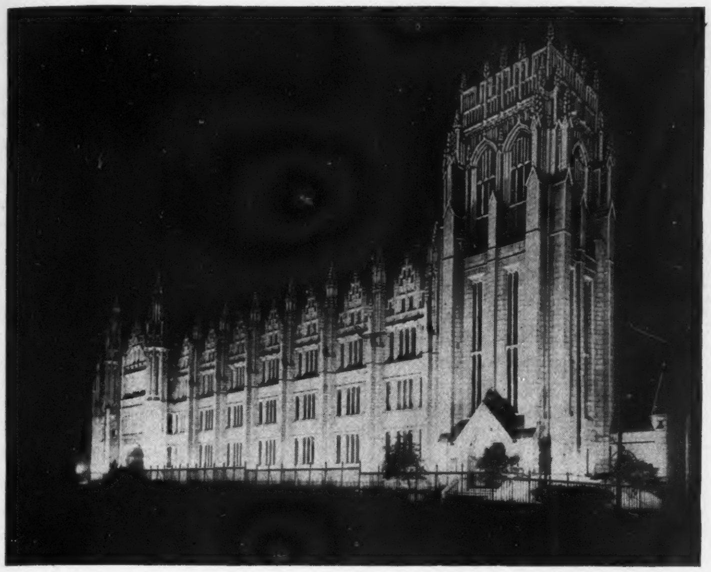
6. Crown Street (Opposite Music Hall).

Revo Electric Co., Ltd., have erected four lanterns. These consist of two examples of their latest "Barnsley" lantern, utilising the new 160° dish combination of refractors and 500-watt lamps, and two Revo "Magnalite" fittings 155°, fitted with 500-watt lamps, which will give a good idea of the efficiency of these units.

(X=42 ft. Y=147 ft. Z=23 ft.)

7. South Silver Street (At Music Hall).

Edison Swan Electric Co., Ltd.—Three Ediswan "London" lanterns, centrally suspended from existing span wires, each equipped with a 500-watt Edi-



Some Night Views at Aberdeen

Marischal College (Aberdeen University) floodlighted by means of thirty-eight B.T.H. projectors, each fitted with a 400-watt Mazda Mercra lamp. The total load was about 16 kw. The main frontage occupies approximately 800 ft., and the light granite of which this fine building is constructed makes it an excellent subject for floodlighting.

A Night view of Union Street, where special Holophane bowl-type prismatic refractors with circular lanterns, and equipped with 400-watt Escura electric discharge lamps, were installed.

A view of Chapel Street, where the Gas Light and Coke Company installed six eight-light low-pressure gas lamps of new design, embodying specially designed Holophane glassware.

A Daylight view, taken from the same spot. The standard carrying the special Holophane lantern is seen in the foreground.

College Bounds, King's College. This fine old building was illuminated by means of Foster and Pullen gas reflector lanterns, each unit containing twelve mantles, and furnishing approximately 4,500 c.p. A very pleasing effect was obtained.

swan gas-filled lamp. The lanterns are of cast-iron and sheet-copper construction, and embody a specially designed bowl refractor entirely enclosed by an outer clear glass globe, which is adequately sealed against the ingress of dust and moisture. A simple focussing device is incorporated.

(X=40 ft. Y=93 ft. and 126 ft. Z=24 ft.)

8. GOLDEN SQUARE (AT MUSIC HALL).

Simplex Electric Co., Ltd.—Three Simplex-Credalux lanterns, No. L.1801, with Holophane Duo-Dome refractors. This open-type lantern is of simple yet robust construction. The lantern is of vitreous enamelled steel construction, with cast-iron canopy and externally operated lead screw focussing adjustment, with asymmetrical two-piece dome refractor. The fitting is stated to operate at an exceptionally high efficiency.

(X=38 ft. Y=144 ft. Z=23 ft.)

9. UNION TERRACE.

The British Thomson-Houston Co., Ltd.—Mazda Mercra lamps in B.T.H. Diron lanterns suspended from nine existing posts. The distribution of light is regarded as particularly suitable for roads of average width. Features of the installation are: (1) The high average illumination, and (2) the comparative uniformity.

(X=50 ft. Y=96 ft. Z=24 ft.)

10. BELMONT STREET.

Engineering and Lighting Equipment Co., Ltd.—Four "Vapoura" fittings with 500-watt (Siemens) gas-filled lamps. This fitting is of ornamental appearance. The globe is composed of rippled opalescent glass of low absorption factor, the stated transmission efficiency of the fitting being approximately 68 per cent. The globe is held in position by a substantial copper spinning, and is lowered by a novel method. The lamps are inserted through the bottom of the fitting. The bottom canopy is copper and no shadow is cast.

(X=37 ft. Y=155 ft. Z=23 ft.)

11. UNION STREET (UNION BRIDGE TO CASTLE STREET).—EXISTING LIGHTING.

General Electric Co.—"Wembley" type of 750-watt lantern, made specially to function on "series wiring" (nine lamps on the 440-volt main), asymmetric refractors set to 160° fitted inside a dust-proof outer pear-shaped globe. The unit is somewhat bright, but the height of the source is a safeguard against glare.

(X=74 ft. Y=130 ft. Z=23 ft.)

12. KING STREET.

The Edison Swan Electric Co., Ltd.—Four Ediswan "Enfield" directional and non-axial lanterns equipped with "Royal" Ediswan Escura Mercury Vapour discharge lamps. The lanterns are arranged in staggered formation on each side of the street, and are each individually controlled by means of cast-iron control boxes containing choking coil, condenser, and switch-fuse, the boxes being clamped to the street standards. The light control is obtained by a combination of refractor glass panels, together with untarnishable metal reflectors at each side, the lanterns being robustly constructed of heavy gauge copper to withstand corrosion.

(X=60 ft. Y=120 ft. Z=23 ft.)

13. KING STREET.

Revo Electric Co., Ltd., give a demonstration of their new 155° Revo "Magnalite" fitting, utilising the Mazda Mercra gaseous discharge lamps, and also the Revo Metrolux gaseous discharge lanterns. Note how the choke and condenser boxes are clamped to existing poles.

(X=60 ft. Y=120 ft. Z=23 ft.)

14. KING STREET.

Simplex Electric Co., Ltd.—Four Simplex-Credalux gaseous discharge lanterns of the panel type, furnished with "Sieray" electric gaseous discharge lamps. The lanterns have been specially designed with a view to overcoming glare, and the design of prismatic panels and interior arrangements is conducive to maximum illumination efficiency. The lantern is constructed from aluminium castings with a hinged top—the double glass panels being fitted to provide a completely watertight assembly. Special prismatic panels can be fitted to give an asymmetric light distribution in accordance with the needs of the installation, with, if required, a reduced intensity in the direction of oncoming traffic.

(X=60 ft. Y=120 ft. Z=23 ft.)

15. KING STREET.

Engineering and Lighting Equipment Co., Ltd.—The new "Highway" fittings, equipped with Siemens H. type electric discharge lamps. The fitting embodies a new system of light control, based on the use of two tilting and swivelling mirrors, in conjunction with opal glass reflecting plates, which enables the distribution of light to be modified within wide limits, so as to conform with the characteristic shape of the road.

(X=60 ft. Y=120 ft. Z=23 ft.)

16. KING STREET.

Electric Street Lighting Apparatus Co.—A few years ago 200-watt "Bi-Multi" lamps were fitted up on tram-car poles, and these glass reflectors have a spread of light at 155°, the primary object of the reflector being to even out the illumination over the whole length of the road rather than to confine it to the immediate neighbourhood of the lamp-posts.

(X=60 ft. Y=120 ft. Z=18 ft.)

17. GALLOWGATE TO COLLEGE BOUNDS.

The lighting of this 'bus route was improved two years ago by the introduction of 64 *Sugg and Co.* "Rochester" suspension 5-light No. 2 mantle high-power low-pressure lanterns, fitted with pear-shaped globes and directional reflectors. The thoroughfare—being very narrow throughout its entire length—has benefited greatly by this scheme of lighting.

(X= 30 to 33 ft. Y=105 ft. Z=14 ft. 9 in.).

17a. JUSTICE STREET.

For description—see No. 17.

(X=50 ft. Y=105 ft. Z=14 ft. 9 in.).

17b. PARK STREET.

For description—see No. 17.

(X=30 ft. Y=105 ft. Z=14 ft. 9 in.).

18. UNION GROVE.

Parkinson and Co.—"1700" Series 10-light suspension lamps, No. 2 mantles (similar to those exhibited at Castle Bromwich last February). For description—see No. 20.

(X=52 ft. Y=105 ft. Z=20 ft.)

The Bromford Tube Co., Ltd., supplied the four steel poles on which the above lamps are mounted. These poles have a seamless steel fluted and stepped shaft, the necessary gear being mounted in the cast-iron base.

19. UNION GROVE

W. Sugg and Co., Ltd.—Four 10-light No. 2 size copper "Rochester" suspension lamps, complete with

A section of the special lighting in Union Street, Aberdeen, by Osira lamps in special lanterns furnished by the General Electric Co., Ltd. Lanterns of the "Lewisham" type were adopted on the length of street from Huntley Street to Bridge Street. Osira lamps in special dispersive opal globes were also installed at the junctions of Bridge Street and Union Terrace.

A daylight photograph of Union Street, showing a near view of the Holophane lanterns illustrated on page 289.

A night view of the fine East and West Church's spire, illuminated by the General Electric Co., Ltd., with high intensity projectors housing Osram lamps. A feature of this pleasing installation was the manner in which the ornamentation and dimensions of the spire were revealed, "flatness" of effect being most successfully avoided.

Horstmann clock controller and constant pressure governor, with flat shade and "S" type directional wings.

(X=52 ft. Y=105 ft. Z=20 ft.).

Stewarts and Lloyds, Ltd., supplied the four steel poles on which the above lamps are mounted. These tubular steel reservoir gas-lighting poles have no internal piping or connections, the poles themselves conveying the gas from the service connections to the lamps.

20. Union Grove.

W. Sugg and Co., Ltd.—Two seven-light No. 2 size upright fixing "Rochester" lamps (in ten-light size casing), fitted with Horstmann's clock controller, and with constant pressure governor. Also supplied two "Arterial" concrete columns, 14 ft. 6 in. out of ground, and two "Boulevard" concrete columns, 14 ft. 6 in. out of ground.

W. Parkinson and Co., Ltd.—Two "1900" Series seven-light "U" fixing lamps. Each lamp is supplied with one gas and air adjuster, operated from outside, heat-resisting clear glass bowls, etc., and fitted with the "Kingsland" clock controller.

(X=52 ft. Y=105 ft. Z=16 ft. 9 in.)

21. Albyn Grove.

Falk, Stadelmann and Co., Ltd.—Four "Warrington" five-light suspension lamps, with superheater, for No. 2 mantles, giving a light of approximately 500 c.p., with a consumption of approximately 14 c.ft. per hour. They are constructed with a copper casing and vitreous enamelled steel reflector. The injector is removable en bloc by releasing a simple locking device. The lamps are fitted with "Gunfire" controllers.

(X=52 ft. Y=90 ft. Z=14 ft. and 17 ft.)

For this installation the *Stanton Ironworks Co., Ltd.*, supplied four octagonal reinforced concrete lamp standards, having hollow interiors and made by a special centrifugal process which ensures great density and resistance to wear. Two sizes, respectively 11 ft. and 14 ft. high (the latter with ladder arms) are shown.

Obtainable in 9 ft. sizes and in various colours.

22. Chapel Street.

The Gas Light and Coke Co. have supplied six eight-light No. 2 mantle low-pressure gas lamps of entirely new design, employing glassware specially developed to bring about the desired light distribution, by *Holophane, Ltd.* The lamps are marketed by *W. Edgar and Son, Ltd., W. Parkinson and Co.,* and *W. Sugg and Co., Ltd.* Each unit in this installation is mounted 24 ft. above the carriageway, and overhangs the latter by 8 ft. The gas consumption is 16 c.ft./hr. (500 B.T.U. gas). Lighting and extinguishing are effected by clockwork controllers by the *Gas Meter Co., Ltd.* The weldless fluted steel columns are supplied by the *British Mannesmann Tube Co.*, and have a cast-iron base with opening door 14 in. by 6 in., with turnbuckle locking device. The raising and lowering gear is by *J. Keith Blackman Co., Ltd.*

(X=41 ft. Y=121 ft. Z=24 ft.)

23. Woolmanhill to Berryden Road.

Foster and Pullen, Ltd.—The improved lighting of this 'bus-route has just been completed by means of fifty No. 520 high-power low-pressure five-light No. 2 mantle lamps, each fitted with "Gunfire" type "D" controller in No. 4 round cast-iron box and stainless steel reflector.

Stewarts and Lloyds, Ltd., supplied the latest type of tubular steel poles. (See also No. 19.)

(X=35 ft. to 50 ft. Y=100 ft. to 117 ft. Z=16 ft.)

24. Schoolhill.

The Lighting Department have just erected a very satisfactory permanent unit for the effective floodlighting of our handsome War Memorial, with two side lanterns for the lighting up of the roadway. The large lantern has two glass mirrored reflectors, fitted each with 500-watt gas-filled lamps, whilst the two smaller lanterns are equipped with 300-watt lamps. These units were supplied by *The General Electric Co., Ltd.*

(Z=27 ft. 6 in.)

25. Broad Street.—Marischal College.

For description see Clause "G."

B.—FLOODLIGHTING

"A." Albyn Place.—Queen's Cross Church.

This very satisfactory floodlighting effect has been produced by means of *Foster and Pullen, Ltd.*, Gas Reflector Lanterns, each unit taking twelve mantles and furnishing approximately 4,500 c.p. The reflectors are within wide limits and the lanterns are made either for horizontal projection or with upward beams, with a variety of fixings, so that they may be used either on the ground, attached to the building front, or mounted on parapets, verandahs, canopies, etc.

"B." Union Street.—Music Hall.

This building is being floodlit by the *Aberdeen Corporation Electricity Department.*

"C." Union Terrace Garden.—Rosemount Viaduct.

The illumination at this point consists of three *General Electric Co.'s* "P.L.A." Lanterns, each fitted with a 500-watt gas-filled lamp.

"D." Schoolhill.—War Memorial.

For description—see No. 24.

"E." Union Street.—East and West Church's Spire.

The *General Electric Co., Ltd.*, are responsible for the floodlighting of this fine spire. Specially designed high-intensity mirrored floodlights, similar to those in use at the floodlighting of various buildings in the South, are used.

"F." Union Street.—Town House.

This building is being floodlit by the *Aberdeen Corporation Electricity Department.*

"G." Broad Street.—Marischal College.

The British Thomson-Houston Co., Ltd., have carried out the floodlighting of the façade of the Marischal College, using Mazda Mercra lamps and special projectors. The Mazda Mercra lamps are of the standard 400-watt type, such as are normally used in a vertical position in street lighting fittings. In this case, however, the lamps are arranged horizontally, thus giving a better distribution of light than could be otherwise obtained. The projectors used in this installation are fitted with a special magnetic control, which, when the lamp is in a horizontal position, prevents the arc from sweeping upwards, and thus causing local overheating of the bulb.

"H." King Street.—North and Trinity Church Spire.

The Ediswan Electric Co. have carried out the floodlighting of this spire by means of eight 1,000-watt Ediswan "Mercury" Floodlight Projectors, equipped with 1,000-watt Royal "Ediswan" gas-filled lamps, together with four Ediswan "Mars" projectors, equipped with 1,000-watt Royal "Ediswan" projector lamps, the projectors being arranged in four batteries of three units per battery round the base of the tower.

"I." College Bounds.—King's College.

For description—see Clause "A."

Lighting Department Practice and Equipment

By

J. M. WARD and J. M. MANN

(Corporation of Glasgow, Lighting Department)

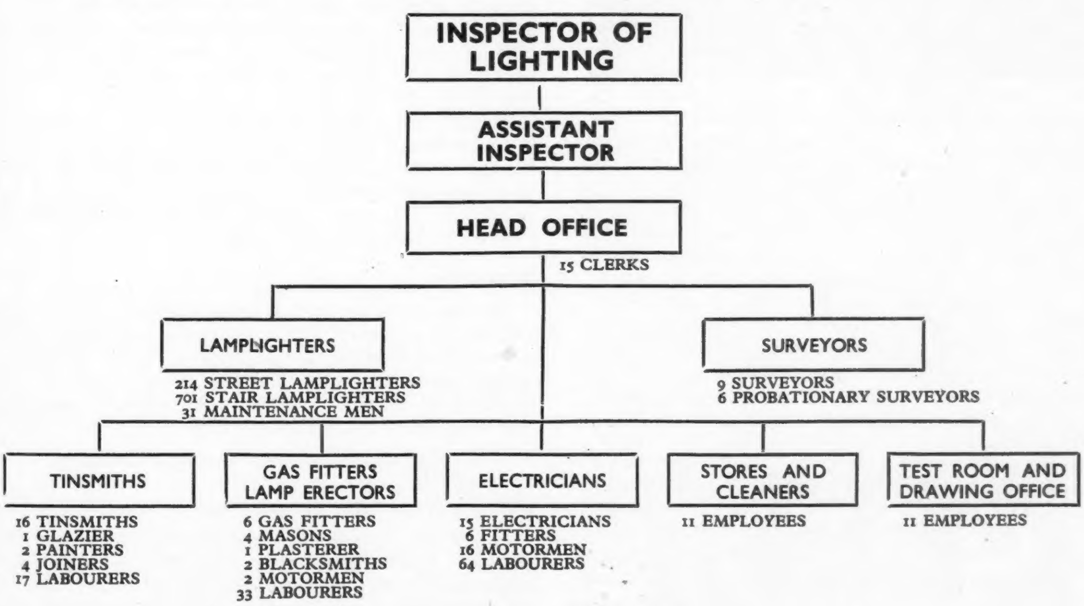
Paper presented at the Eleventh Annual Meeting and Conference of the Association of Public Lighting Engineers, held in Aberdeen during September 17th to 20th, 1934.

In selecting this title, "Lighting Department Practice and Equipment," we have been influenced by the desire to present a paper which will be of real practical interest to those engaged, or interested, in Public Lighting. We hope to succeed in this, since the paper will consist for the most part of the experiences, experiments, and progress made by the Glasgow Corporation Lighting Department—a very old-established department, having been in existence for over a hundred years. There has been a Lighting Department in Glasgow since 1800, and an old Order Book covering the years 1819-1839 contains some delightful items of a period when life pursued a more leisurely course than it does to-day. In 1819, we find it laid down that "The lamplighters are to start the valves of the gas pipe with their hands, and not with their ladders, under penalty of a shilling for each offence." So we find the lamplighter at his little tricks in those far-off days! These orders were issued by the Board of Commissioners of Police to the Superintendent of Lamps.

It is necessary at this point that we should quote the Department's charter, otherwise the practice here outlined may appear to many as unnecessarily costly and extravagant. Acts of Parliament dealing with the street-lighting of Glasgow are to be found earlier than 1866, but the "Glasgow Police Act" of that year was the Department's real charter, and empowered the Corporation "to erect and maintain lamps, lamp-posts, and other appurtenances for lighting in a suitable manner, all public and private streets, courts and common stairs within the city, to light the dial plates of turret clocks and city timepieces, and to appoint an Inspector of Lighting to take charge of that work and be responsible for the good conduct of the lamplighters and others appointed by him." In this old Act it is interesting to note that powers were given "to affix to the walls of any buildings, or the railings in front of such buildings, the necessary lamp-posts, lamp irons and other appurtenances." Where a central suspension street-lighting installation is being contemplated the advantage of such a clause is obvious.

The close relationship between the services of Police and Lighting is shown by our occupancy of part of the police stations for divisional offices and lamp-lighting muster halls in certain districts of the city. Until a few years ago the responsible Committee was the "Watching and Lighting Committee," but this has now been changed to "Police Committee," with a sub-committee taking under its wing both the Fire Brigade and Lighting. With its roots well established in the nineteenth century, it is not surprising that the Glasgow Lighting Department of to-day should be a tree of vigorous growth, and a survey of its branches should be of interest.

The total staff numbers 1,189, and the following diagram gives some idea of the scope of the Department's activities, and indicates the sections under which it has been found convenient to group the staff, for efficient control.



Head Office.

A department is best served by giving competent superintendents full authority in the control of their sections. This is the policy carried out by the Glasgow Lighting Department, but a very careful supervision is kept by the Inspector of Lighting with the assistance of the Head Office Staff. The foremen must keep the Inspector and Head Office well advised of their activities, and, to facilitate this, each has a branch telephone to his office. The primary functions of the Head Office are:—

(1) To assist the Inspector of Lighting to keep strict control, and to keep him advised of the activities of each branch.
(2) To keep necessary and useful records.
(3) To estimate and spend wisely.

This last function is, naturally, a most important one, and calls for very careful thought and care, since our annual expenditure on street and stair lighting amounts to £320,000. With such a large sum involved, it is imperative that our system of accounting should be an efficient one.

Under the Glasgow Police Act of 1866, to which we have previously referred as our charter, the expenditure on the lighting of public streets was met from a "General Police Assessment," but not so the lighting of common stairs, courts, or private streets; the cost of which had to be recovered from the individual proprietors concerned. This arrangement, besides giving endless trouble, was proving a formidable obstacle to lighting improvements. Steps had therefore to be taken to have radical alterations made, and powers were obtained, under the Glasgow Corporation Confirmation Act, 1914, to levy an assessment for all lighting services in Glasgow, with a limit of 6d. on the £1. This was subsequently raised to 9d. in the Confirmation Act of 1923. From that date our actual lighting rate has been:—

1924-25	7.02 pence.
1925-26	6.1 „
1926-27	6.86 „
1927-28	8.97 „
1928-29	7.53 „
1929-30	7.34 „

No further figures are available since 1930, as that year saw the beginning of the Local Government (Scotland) Act, 1929, introducing the "Consolidated Rate," and Section 19 expressly states that: "All rates leviable by a rating authority shall be levied and recovered as one rate, to be known as the 'Consolidated Rate.' The total monies raised by this rate shall be paid in the case of a burgh into a fund to be called the 'Burgh Fund,' and the expenditure of the town council payable out of rates for each branch of expenditure shall be defrayed out of such fund." So the Lighting Rate disappears from available statistics, but remains as a limit on the total expenditure on public lighting. It is important to note that in Glasgow all our departmental expense, with the exception of "Purchases of Buildings and Sites," is debited to Ordinary Revenue and Expenditure Account. It was the practice, however, in former years to transfer annually a sum from this account to capital account to cover expenditure incurred in new lighting schemes, and improvements in existing plant. The auditors, having questioned the validity of these improvements as assets, it was decided to meet all public lighting expenditure with the aforesaid exception from the income derived from the annual levied rate. As a result of our former practice the Department has an accumulated debt of £50,000, and has to meet an annual sum of £4,800 for interest and sinking fund. The present practice is certainly sound finance, but the chief drawback, we find, is when uninformed citizens and associations begin comparing the expenditure of town A with town B, ignoring the fact that the financial arrangements differ and comparisons are unfair.

The actual payment of accounts and paybills is made by the City Chamberlain, so that the only cash transactions carried out by the department are those in the sales ledger, and amount approximately to £9,000 per annum. These for the most part consist of revenue obtained from: (1) Lamps owned by private individuals, such as doctors, and charged against them; (2) sales of scrap metals and obsolete plant; (3) work done and materials supplied to other departments and councils; (4) damaged lamps. Lamps knocked down or damaged by vehicles in Glasgow are daily occurrences, and the total value of claims against motorists, etc., last year amounted to £1,300. For many years now we have agreed to accept two-thirds of the amount of these claims in full settlement when they are being met by insurance companies or large contracting bodies, on condition that they will never dispute any of our claims whatsoever. The loss we incur is amply repaid by saving in collection costs and the expense of disputed claims, for often our evidence is slight and many of them would be difficult to press.

Our system of accounting with reference to gas and electricity is worthy of some attention. The gas we purchase from the Corporation Gas Department, but not only do we purchase current from the Corporation Electricity Department, but we are also large consumers of a public joint stock company. A monthly return is made to all these bodies of all new lamps, lamps discontinued, and any increases in cubic feet or wattages. We also advise them of any departures made from the fixed lighting scale owing to fog or early darkness. Our basic annual scale of burning hours in Glasgow is 3,711, but the actual burning hours for the past three years has been 3,856, 3,844, 3,824. Quarterly accounts are then rendered to us by these undertakings calculated on

No. of lamps x consumpt. $\begin{pmatrix}\text{cubic feet}\\ \text{watts}\end{pmatrix}$ of each x No of burning hours.

This method of charging has been in operation with the Corporation Departments for many years, but when we first became consumers of the public company it was necessary to convince this supply authority, by argument and records of readings from meters installed in a few circuits, that if our system erred at all, it was in their favour.

Stores.

Stores are issued on receipt of requisition forms from foremen, and goods are purchased from requisitions issued from the store to head office. Stores ledgers are kept and accounts opened for all goods, so that stocks are readily ascertained, and periodical checks can be made by head office of goods received and issued. A stores day book is written up daily of all goods received, and no account is passed for payment unless the appropriate entry is to be found in this book. The account is initialled by the stores assistant, and the day book by the purchasing clerk, and the account finally certified by the head of the department. With three persons involved, collusion is unlikely.

Tinsmiths.

This section performs many varied duties, including metal work for other sections, and sometimes for other Corporation Departments, such as repairing police hand lamps, road repair danger lamps, and the making of direction signs. A suitable grouping of the work carried out would be:—

(1) Overhauling defective gas burners.
(2) Making new lanterns.
(3) Repairing gas lanterns.

(1) With 91,000 gas burners in daily use in the streets and stairs, this branch, which employs eight men, has always plenty of work on hand. The burners must, of course, be kept in good condition by the lamp-lighting staff, but all those showing signs of "wear and tear," or developing defects, are sent in daily to the store from the divisional offices, and an equal number of reconditioned burners are supplied in their place. While the streetlighters (full-time employment) are responsible for the cleaning of their own burners, the stairlighters (part-time employment only) are exempt, and their burners are cleaned by a special maintenance staff. Only four types of burners are used in any quantities, and parts for renewal are inexpensive, and not too numerous.

(1) Stair burner consuming .7 cu. ft. per hour.
(2) Single swan neck burner consuming 2.8 cu. ft. per hour.
(3) 3-Light roof burner consuming 5.5 cu. ft. per hour.

(4) 4-Light roof burner consuming 6.75 cu. ft. per hour.

The canopy of the stair burner is made of cast iron, and, after a period of service on the stairs, is brought in for heat treatment. A gas-heated muffle furnace is used, and the castings heated to approximately 700° C. After cooling, they are brushed to remove scales, and painted with aluminium paint ready for re-assembling. The brass parts are cleaned with nitric acid, and the street burners, being mostly brass, are also treated in the acid bath.

The reconditioning completed, the burners are each tested at 26/10ths pressure for their stated consumpts, and the nipples adjusted until this is accurately registered. To ensure accurate consumpt the Gas Department formerly supplied governors for fitting to street lamps, but have now ceased this practice, and the 2.8-ft. burner is not now fitted with a governor. The 3-light and 4-light roof burners (mantles in alignment) to which we are rapidly changing over, are all fitted with pressure governors set for 3-in. to 7-in. inlet pressure and 26/10ths outlet. These governors, however, are provided and maintained by the Lighting Department to maintain the high efficiency of these burners. Our experience of governors of this type has been very satisfactory, and apart from the periodic oiling of the leather diaphragm, repairs are negligible.

(2) Except in the first rush of the change over from the old round globes to the square lantern, our tinsmiths have made all the gas lanterns used in Glasgow streets. An early experience proved that tin was absolutely useless to withstand service conditions, and copper has been used exclusively. Two sizes are made and the dimensions of the lantern

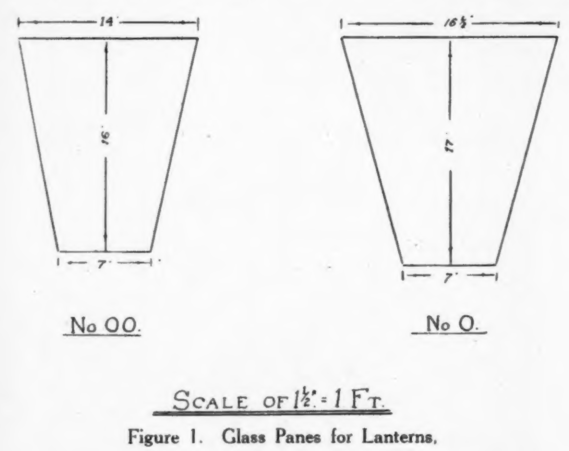


Figure 1. Glass Panes for Lanterns.

panes are shown herewith (Fig. 1), the No. 00 size for 3-light and No. 0 for 4-light burners.

No exceptional features are embodied in the lantern, but they are built for their job, and as our records show they do it for periods of fifteen to twenty years without repair. With the exception of the brass bottom trap door and the astragals, which are of brass encased in soft copper, the lantern is of 24-w.g. bright rolled copper throughout. To facilitate handling by the lamplighter in cleaning roof-light lanterns by giving him a firmer hold to raise the top, a small bolted iron handle takes the place of the usual but less secure knob. It is the kind of lantern we feel sure the manufacturer would like to turn out, if price-cutting left him no option but to produce a lantern perhaps a little less substantial. A more recent product of this section are traffic lanterns of the "Keep Left" type as shown. (Fig. 2.) In Appendix III., diagram IV., of the Report of the Departmental Committee on Traffic Signs (1933) a "Keep Left" notice is specified (Fig. 3), but nothing is laid down as to "housing" such a notice where it is internally illuminated.

In Glasgow the City Engineer has adopted a sign with the dimensions exactly twice those shown. The glass used in this lantern has white letters on a blue background, and one difficulty experienced with this combination is the necessity for using two panes—

Figure 2. Keep Left Lantern.

blue with the letters etched and an opal back pane. Panes combining the blue and white on the one glass have not been satisfactory, the blue fading out when illuminated, especially surrounding the large white area of the two E's. It is hoped that the glass manufacturers will take note, and at an early date make available the necessary "one glass" pane.

(3) Erring motorists are responsible for keeping this section busy. In Glasgow, during last year, 600 lamps were smashed, and although the pillar may only be dislodged it is very seldom that the lantern is not damaged and ready for a visit to the hospital at 20, Trongate. The motorist, of course, tries bigger

Figure 3. Dimensions of Sign as recommended by Departmental Committee on Traffic Signs.

"game" sometimes, and one splendid effort is shown. (Fig. 4.)

Lamp Erectors Section.

With almost 1,000 poles to erect per annum, and the majority of them in housing schemes on the out-

skirts of the city many miles apart, the question of a mobile crane became a very pressing one. At this time the erection of poles was carried out by a 2-ton hand crane (see Fig. 4) mounted on a horse-drawn

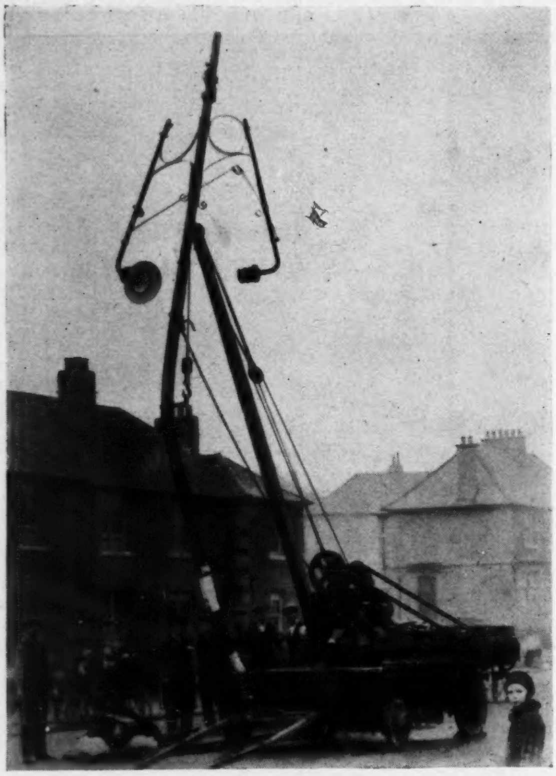


Figure 4. A motorist's effort, showing old type of Crane at work.

lorry. The crane and the necessary ballast of forty 56 lb. weights represented a heavy load for one horse, and movements were slow and laborious.

The makers of mobile cranes were approached, and tests carried out with their standard models. The cranes certainly proved marvellously mobile, but they did not exactly meet our requirements in Glasgow, where tram lines abound to so great an extent, and the distance between tram line and kerb determined the area in which it was possible to carry out our manœuvres.

Following the tests and discussions, one of the makers came forward with drawings of a crane

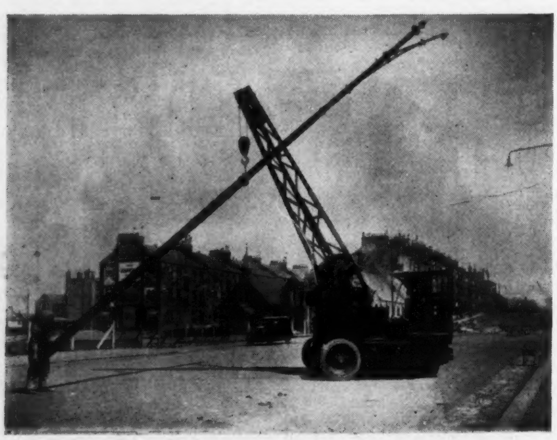


Figure 5. Mobile Crane with 37 ft. Steel Pole and Bracket.

which they felt would do our job, and on the strength of their reputation for this type of work an order was placed, and a photograph of the crane is given in Fig. 5. The crane has a maximum capacity of two tons. With jib angle most suitable for handling the 37 ft. steel poles so largely used by the Department, 30 cwt. is the maximum load. The weight of this pole complete with bracket is 8 cwt., so that there is a good margin of safety. The crane travels on four rubber-tyred wheels, and has a road speed of six miles per hour, and is equal to all gradients to be negotiated in Glasgow. The four motions, derricking, hoisting, slewing, and travelling, are each operated by separate motors. The primary drive is by a petrol engine coupled to a generator which supplies five motors, i.e., the three above mentioned and the two four h.p. travelling motors. All these are energised by direct current at voltages varying between zero and 250.

The actual erection of a pole of the length and weight indicated is the kind of job where experience tells. In Glasgow, having had plenty of practice, our pole squad have certainly attained remarkable proficiency in this work. Apart from the special calls we sometimes have to make on the squad to go "all out," it is no mean performance for six men in one day to do the necessary excavation work and erect five poles complete with bracket arm and scroll work. The best testimonial to the success of the crane is the proposal by the Transport Department of the city to secure one for their erection work.

For the excavating work, special long-handled spades and spoons of the type illustrated in Fig. 6

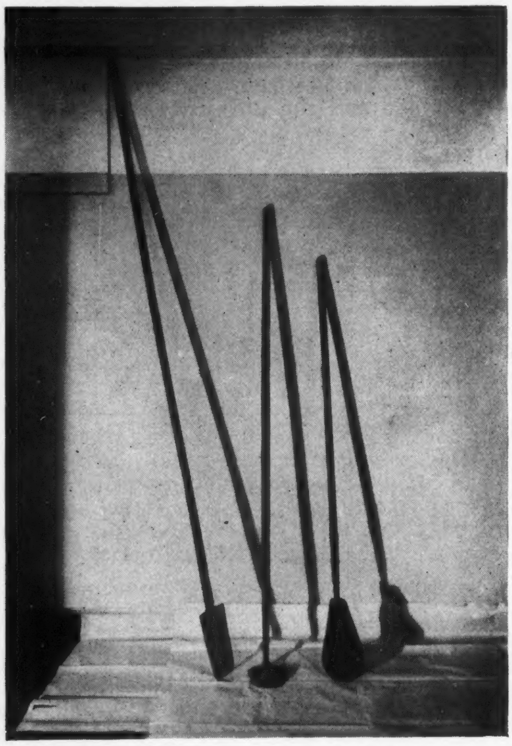


Figure 6. Tools for excavating work for pole erection

are used. The hole is generally 6 ft. deep, unless rocky sites necessitate modification. When the pole is placed in position the aggregate is shovelled into the hole, and the necessary water poured in. It might be thought that there was a certain amount of risk with such a method, but such tests as we have carried out have proved conclusively that not only is there a saving of time and cement in this way, but that a thoroughly satisfactory pole anchorage results. Yet another advantage is that this method prevents cement being washed into the gullies, a proceeding which you may be sure does not receive the approval of the City Engineer.

With the rapid change from cast iron to steel tubular standards, Lighting Engineers will find

themselves confronted with all the problems of metal preservation. At any rate we are finding things so in Glasgow, and in planning the papers for future meetings, one on this subject might well be considered. All steel poles purchased by the Department were supplied with one coat of red lead. Unfortunately there is a tendency to confuse "red lead paint" with a coating of red lead, and the results can be disastrous. On erection the poles received one coat of good quality green glossy paint. When issuing tenders for steel poles, two coats of red oxide to B.S.I. specification are stipulated, and the quality of glossy green paint employed has been the subject of many and varied tests.

Electrical Department.

This section, although the youngest, has grown so rapidly that it is now the largest. From a section comprising a few men doing maintenance work only, it has grown rapidly within recent years to its present complement of 101 employees, who not only clean globes, renew lamps, repair faults, but carry out the complete installation of street lighting circuits. No work, other than the provision of a supply into the Lighting Department section box, is now undertaken by the two supply authorities in Glasgow. Figs. 7 and 8 show the interior of one of these section boxes erected and fitted by this department with relay apparatus and emergency hand circuit switches.

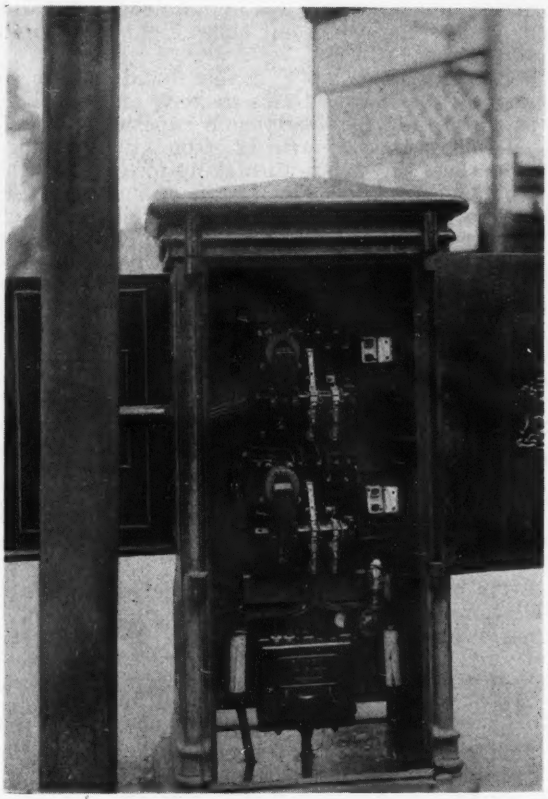


Figure 7. Showing Section-Box with Relay Switching Gear.

Our experience of underground cabling has not been a very favourable one, and practically all the cable now erected for street lighting is overhead, as it has the following advantages: —

(1) The system is at any time easily accessible.
(2) Temporary repairs can be quickly effected, during the night if necessary.
(3) Maintenance is much simpler, faults being less liable to occur, and very much simpler to detect.

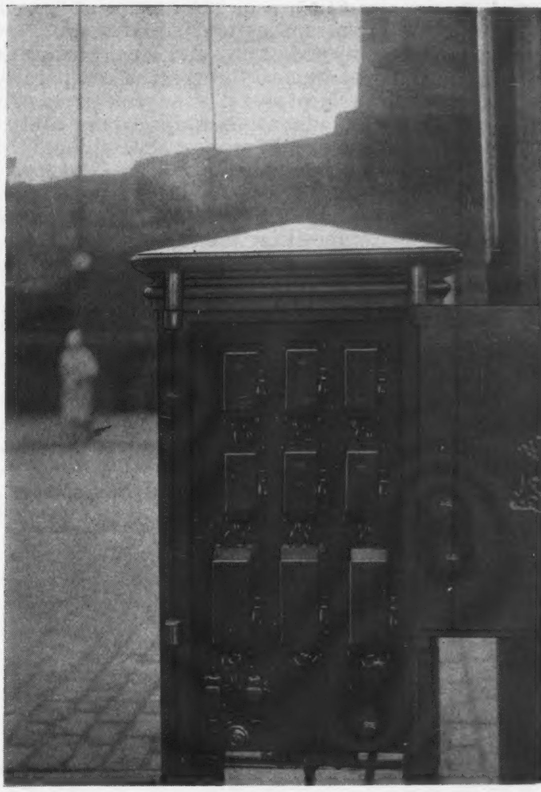


Figure 8. Reverse side of panel (Figure 7) showing Emergency Hand Switches.

(4) Maintenance costs are therefore very much smaller.
(5) The cores being not less than 6 in. apart, short circuits are less likely, and there is more freedom from chemical and electrolytic action.

The one strong objection to overhead cable is, that it is unsightly. This objection must be considered

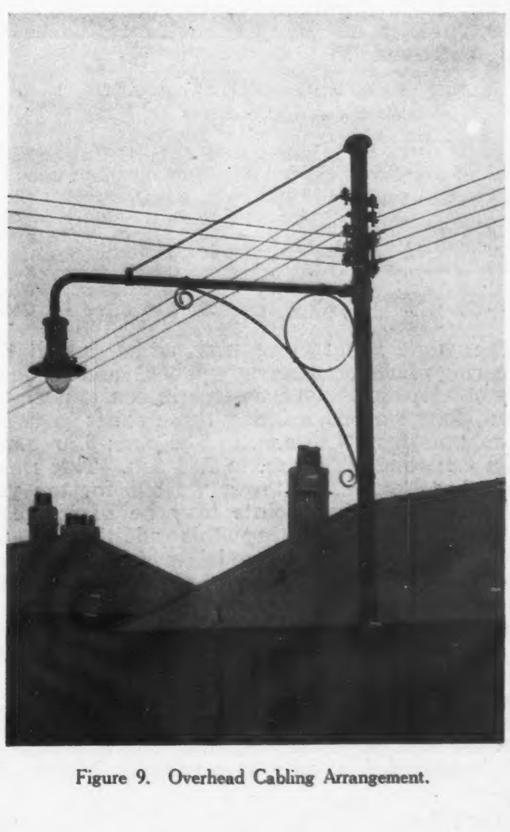


Figure 9. Overhead Cabling Arrangement.

in certain areas which are of the nature of "show" places, such as open spaces and squares, but with adequate lighting so necessary, and local authorities holding the purse strings so tightly, the comparative cheapness of an overhead installation, compared with the very much more expensive underground cabling, will no doubt overcome the appearance objection in ordinary streets. The cable used in Glasgow is No. 10 S.W.G. single core hard drawn copper conductor, with pure and V.I.R. insulation, braided and compounded. Composition insulators of a good quality are used, these being preferred to porcelain ones after many long tests had been carried out. It is essential, however, that the quality should be good, as many ineffective composition insulators are on the market. Fig. 9 shows the method of fixing the aerial cable to the pole.

While making use of time switches in certain circumstances for electric street lighting control, our policy has been to concentrate on central switching control by means of electric relays, this being the most advantageous in this very unreliable climate of ours. The following weekly report of the "switch-

Figure 10. Latest Type Motor Tower Wagon and Hand Tower.

ing on" times of a control board which operates over 2,000 lights, clearly shows the advantage over clock and hand control.

ELECTRIC CONTROL BOARD.
Week ending December 22, 1933.

Date.	Lighting. Scale Time.	Control Time.	Difference from Scale Time.	Weather Conditions.
15/16	3.15 p.m.	4.13 p.m.	58 mins. after	Clear
16/17	,,	3.33 ,,	18 ,, after	Foggy
17/18	,,	3.7 ,,	8 ,, before	Foggy
18/19	,,	4.5 ,,	50 ,, after	Clear
19/20	,,	3.15 ,,	0 ,,	Foggy
20/21	,,	3.57 ,,	42 ,, after	Clear
21/22	,,	4.5 ,,	50 ,, after	Clear

The work of erecting new aerial installations, repairing faults, cleaning globes, and renewing lamps, keeps six tower wagons in constant employment, four wagons working three shifts in twenty-four hours from 7.45 a.m. to 5.30 p.m.; 5.30 p.m. to 12.30 a.m., and 12.30 a.m. to 7.30 a.m. This Department has been using tower wagons for ten years, and the following points may be of interest to authorities contemplating this addition to their equipment. The latest model, which naturally included all the good points of the older ones, has been fitted with power-driven elevating gear. Power is taken from the gear box, and transmitted by means of shafting to pinion wheel of the elevating screw. Balance weights are fitted which work on rails on the stationary section of the tower. The raising and lowering of the platform is regulated by a control lever at the rear of the wagon, and an automatic cut-out is provided to stop at maximum height. This wagon is a vast improvement on previous ones, as will be readily seen by comparing the operating times with that of a hand raised tower wagon.

Power elevated—30 secs. to maximum height.
Hand elevated (2 men)—3 mins. to maximum height.

Even on hand operation this machine, because of the balance weights, is much faster, being raised by one man in 1 min. 20 secs. Mounted on a 30 cwt. chassis the overall length of the vehicle is 17 ft. 6 in. The wheel base is 10 ft. 9 in. by 5 ft., and the general design can be seen from the photograph (Fig. 10). Immediately behind the driver's cabin, which accommodates three people, there is press accommodation which must be ample for carrying renewal stocks of large-wattage lamps. The tower structure is in four sections, giving an extended height from ground to platform of 30 ft., and a closed height of 12 ft. 6 in. The platform 5 ft. square is stationary, since a turn-table arrangement at such a height would be dangerous. The nature of the work performed is not conducive to a high mileage per gallon, and the average works out about eight to ten miles to the gallon.

For maintenance work a few hand towers are employed, made by various makers, and our latest is shown in Fig. 10. Here again experience has dictated not a few departures from the catalogue article, some slight, but all making for ease of working and longer life. For instance, increasing distance between platform and guard rail allows employee to pass through instead of climbing over rail. A trifling matter one might say—but not to the man working on top in all kinds of weather. Tool trays as generally provided are too shallow for safe working. A spanner dropping from 30 ft. on a passing citizen is not unlikely to involve the Department in heavy damages, so we specify a minimum depth of 4 in. By fitting metal shields on the rungs of the middle section, where excessive wear was occasioned through the rubbing of the automatic locks, we eliminated a source of constant trouble. We always specify levelling jacks on all legs. The foregoing we have instanced as showing, no matter what the article, improvements can be effected by close co-operation between maker and user.

After exhaustive tests on completed electric installations the policy was adopted of renewing all electric lamps of wattages from 150-1,000 after burning 1,000 hours. With over 9,000 of these high-wattage lamps, and increasing at the rate of 800 to 1,000 per annum the clerical work involved by this decision would have been considerable if an ordinary card system had been used. By installing a "visible" card index system, with a card for each lamp, and employing "signals" to record 1,000 hours, the work of systematic lamp renewals is effectively carried out with the minimum of clerical labour. The operating of the "tote," as it is familiarly called, is only a part-time job for a junior, although it now records the behaviour of 9,000 lighting units with an annual lamp bill of £10,000. At a glance, the tote immediately reveals an invaluable check on the life of lamps used, and the behaviour of certain makes and certain wattages; but the greatest advantage is the easy method it provides of drawing up lists of lamps for renewal after burning 1,000 hours. The advance signals used show these at a glance, and by a carefully arranged grouping of these lists, the maintenance staff work of renewing is kept down to a minimum, since the travelling done by the tower wagons is confined to a single street or area. As a result of the above procedure, the "darks" or casualty lists, as they are called, are surprisingly small, and for the first seven months of this year the average number of dark lamps to be renewed each evening has been only .3 per cent. of the total.

The introduction of this system found us involved in discussions of lamp life with the makers. When

the operator records the daily casualty list, he has before him a scale which gives him the actual hours the lamp has burned, and he notes in a Premature Failure Book under the maker's name, all lamps which have given less than 600 hours. Confronted with these lists showing these premature failures the makers, of course, wanted to examine the lamps, and resulting from these examinations we had to tackle a real problem—failure from access of water. We were assured that this was the first time that any manufacturer had ever heard of water shortening the life of the lamp in such a manner. With this clue a graph was made based on the casualties each day, and with the kind assistance of the Parks Department who placed the rainfall charts for that period at our disposal, we also made up a graph of the rainfall. These two graphs are shown together herewith (Fig. 11), and the striking similarity between the two is clearly shown.

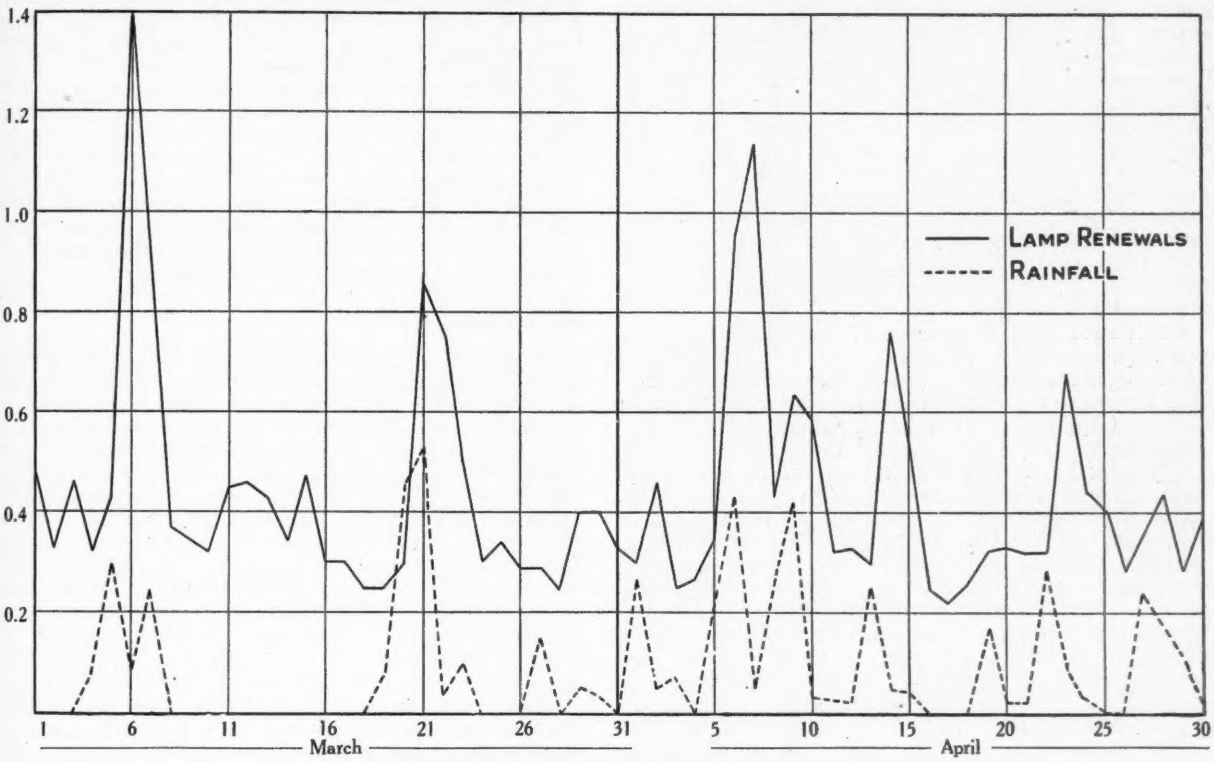


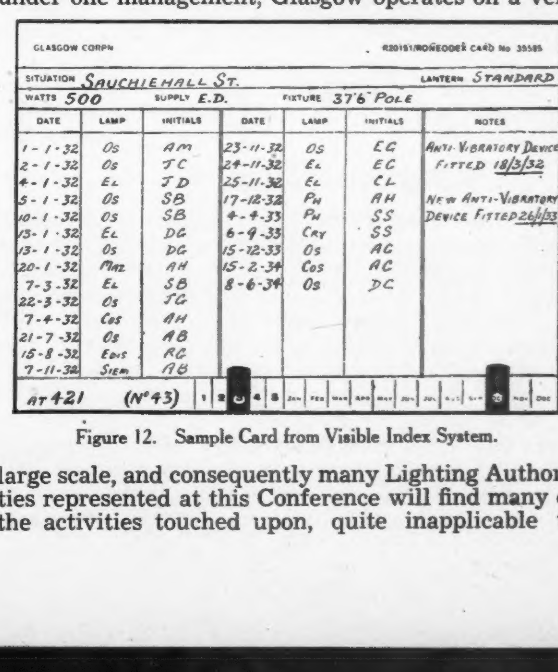
Figure 11. Rainfall and Lamp Renewals. March and April, 1932.

The water problem was tackled in earnest. Bracket designs and the position of the cable entry holes were altered, for we found that with overhead cable the drop of the cable to a side hole had provided a lead-in for water. Having discovered other authorities with similar complaints, one lamp manufacturer made a very useful contribution to the solution—namely, a differently shaped bulb, which although it might still receive the drops of water, would receive this destructive element on a section of the surface where a more even temperature prevailed. In the older type of bulb the water had impinged at a point where a condition of stress existed, due to the differing temperatures above and below the mica disc, with resulting fracture of the glass.

The periodical examination of the cards has shown some units with excessive consumpt of lamps. These are reported to the Electrical Superintendent for examination and report. Should the report show that the lantern, wiring, and fittings are all in order an anti-vibrator is fitted. Our experience in Glasgow has been that different vibrations call for different anti-vibrators. An example of a rather stubborn unit which finally yielded to treatment is shown on a card taken from the visible card index and reproduced in Fig. 12. The dates given record the renewal of lamps, and it will be seen that a partial recovery was made by fitting an anti-vibrator, but it was not until another type had been fitted that the recovery was complete, and the unit began to give a full life of 1,000 hours. The signals at the foot of the card which are visible as they lie in trays, show at a glance that the present lamp is due for renewal in the third week of October.

Divisional Offices.

The present arrangement existing in Glasgow of dividing the city into thirteen lighting areas with a district office in each is a survival of an all gas system, but with the extension of electric lighting, steps are being taken which will eliminate at least half of this number. By combining street and stair lighting (making a total of 125,000 lighting points) under one management, Glasgow operates on a very



GLASGOW CORPN — R20151/RONEODEX CARD No 35585

SITUATION SAUCHIEHALL ST. — LANTERN STANDARD

WATTS 500 — SUPPLY E.D. — FIXTURE 37'6" POLE

DATE	LAMP	INITIALS	DATE	LAMP	INITIALS	NOTES
1-1-32	Os	AM	23-11-32	Os	EG	ANTI-VIBRATORY DEVICE FITTED 18/3/32
2-1-32	Os	TC	24-11-32	EL	EC	
4-1-32	EL	JD	25-11-32	EL	CL	
5-1-32	Os	SB	17-12-32	PH	AH	NEW ANTI-VIBRATORY DEVICE FITTED 26/1/33
10-1-32	Os	SB	4-4-33	PH	SS	
13-1-32	EL	DG	6-9-33	CRY	SS	
13-1-32	Os	DG	15-12-33	Os	AC	
20-1-32	Maz	AH	15-2-34	Cos	AC	
7-3-32	EL	SB	8-6-34	Os	DC	
22-3-32	Os	JG				
7-4-32	Cos	AH				
21-7-32	Os	AB				
15-8-32	Edis	RG				
7-11-32	Siem	AB				

AT 421 (No 43) 1 2 3 4 5 JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Figure 12. Sample Card from Visible Index System.

large scale, and consequently many Lighting Authorities represented at this Conference will find many of the activities touched upon, quite inapplicable to

their conditions. We think, therefore, that it might be advisable to give the routine work of these district offices in some detail, as their areas, comprising in some cases 3,000 street lamps and 6,000 stair lamps, touch the other end of the scale of Lighting Departments. Each division has a superintendent in charge, and besides his office there is ample accommodation for the lamplighters in the muster hall, which is fitted with forms, ladder and torch racks, and a lead covered bench for trimming lamps and torches. Store accommodation is provided, but the stocks of mantles, lamps, burners, etc., carried, are kept as low as possible.

Clock dials in the muster hall make known to the lamplighter the prevailing times for lighting and extinguishing. The men are despatched in groups according to the time required to reach the first point on their beat at scale time, and as each batch leaves, the superintendent records the time on a "Despatch of Men to Light" form (appendix No. 1). This is one of the most important records we have in Glasgow, and its production has been an important factor in some of the cases we have contested as to our liability for accidents on streets and stairs. The same form records any departures from scale time authorised from the Head Office or at the superintendent's own discretion. The number of lamps per beat averages 120 when all gas, increasing in number with the introduction of electrics until the figure of 500 is reached for an all electric beat of units on small standards.

On the return of the men oral reports are made to the superintendent of defects requiring attention, such as gas obstructions, glazing, burner repairs, etc., and these are transferred by him to Maintenance Lines (Appendix II.), Tradesmen's Worklines (Appendix III.), and Glazing Contractor's Lines (Appendix IV.). The glazing is done by a private firm, tenders being sent out each year for this work. As a result of the close co-operation in Glasgow between the City Engineer's Department and our own, the lamplighters have been trained to report on quite a number of matters not strictly lighting, but Corporation interests, nevertheless. Following the nightly reports, the superintendent's mail to head office next morning will often contain, besides the above worklines, reports of "missing water tobies," "broken stair rails," "defective steps and stairs," "uneven flagstones," and "defaced name tablets."

The lamplighters do not report at extinguishing time, but a time-keeping check is kept by a system of collecting checks. Each stairlighter must hand over a check to the streetlighter operating at the nearest point to his beat. This system has proved a very effective one. Roll-call of street lamplighters takes place at 10 a.m. each morning, when time-keeping checks are handed in, further reports made, and supplies of mantles, electric lamps, etc., issued to replace those fitted. The streetlighter then proceeds to his cleaning and renewing of mantles and lamps. Stairlighters being part-time employees, report only at the beginning and finish of lighting-up time. These stairlighters are paid 35s. 2d. to 40s. 2d. per week, and their further duties consist only of keeping globes clean. Their maintenance work is done by a special staff, paid at the rate of 55s. per week (full-time employment), and they look after, approximately, 2,000 stair lights. Streetlighters receive 55s. per week, increased to 56s. after one year's service, and they are provided with the following uniform clothing:—

1 Uniform and extra trousers every year.
1 Overcoat every two years.
1 Waterproof every four years.

Each month the superintendent makes returns of mantles, electric lamps, and globes used, and also his present stock of these materials. From the figures he submits he, in return, receives a report from the head office, informing him of his average monthly consumpt of these materials, and how this compares with the average over the whole city. At intervals his stock will be checked by a clerk from the head office. Streetlighters now use carbide torches exclusively, with their advantages over oil of being cleaner, quicker to light, and their distinctive advantages in gusty weather. Stairlighters still use oil lamps of a special design. Experiments have been made with electric hand lamp torches, but they have not so far proved robust enough for our use.

Surveying.

Bearing in mind that our lamplighting staff is very large, and their work scatters them over 660 miles of the city's streets, an adequate personal supervision is impossible, and to maintain discipline and efficiency it is essential that a staff of surveyors should be employed for this purpose. This staff consists of nine surveyors and six probationary surveyors. They have all started at the bottom of the ladder, and have thus years of experience as stair and street lamplighters to fit them for their work. They spend about $5\frac{1}{2}$ hours each evening surveying and noting the condition of street and stair beats, dark lamps, etc., and next morning they spend about $1\frac{1}{2}$ hours writing up their reports, on special report forms (Appendix V.), for the attention of the Inspector of Lighting.

Some years ago, when the Corporation decided to give street lamplighters one day off in six weeks, a system of probationary surveyors was begun. Six good type streetlighters were selected, and each streetlighter is relieved for his day off by these surveyors doing his lighting and extinguishing. Each day, therefore, these surveyors have gone over a beat, and they make their report regarding the condition of it. As a survey it is excellent, and many points which the ordinary inspection misses are revealed, such as plant defects, stiff or excessively loose cranes. Should any tendency to slackness on the part of the

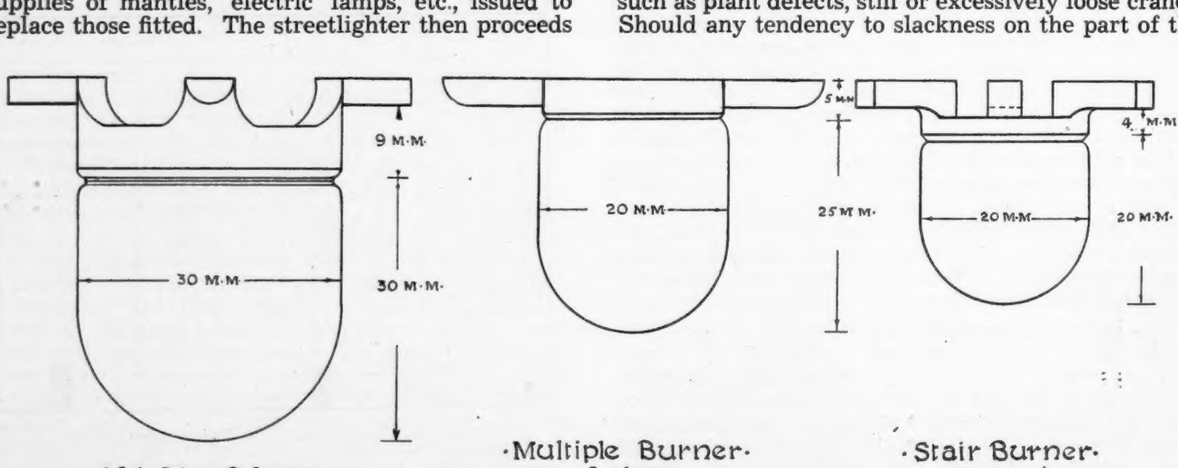


Figure 13. Three sizes of Mantles used by the Department.

lamplighter be shown by the various reports when examined by the Inspector of Lighting, a "Defaulter's Report" is called for (Appendix VI.). That no undue hardship should be caused, an additional form (Appendix VII.) is presented at the same time to the Inspector, and this shows the previous reports of this man's beat. In this way an employee's first falling off is noted, and a word of caution is usually all that is necessary to set him on the right road again.

Test Room and Drawing Office.

The present activity in housing keeps the drawing office fully employed preparing plans showing the proposed positions of the lamp standards, mounting heights, types of suspension, cabling and control wiring, supply points, and control positions. A copy of each plan is given to the foremen concerned in the erection of the installations, and another is filed for reference.

The necessity of having a test room attached to a Lighting Department is one which is often urged. We should like to emphasise the importance of making a start in this direction, even if this should only be in a very small way at first. If engineers can persuade their committees to set aside the necessary monies to equip a small test room, with the correct personnel, it will not be long before the investment will be yielding handsome results and providing an incentive to proceed with further equipment. Those who have had the privilege of visiting Watson House will readily understand what can be accomplished by a well-equipped testing station.

Our own test room was started over twenty years ago with a photometer and some essential material testing apparatus. It was not long before this new section proved its value, with the result that we have gradually increased the equipment and staff to cope with the work of: (1) Testing of materials used in considerable quantities, and (2) the required experimental and research work so very necessary in public lighting.

Extensive tests are carried out in the laboratory with all types of burners, lamps, lanterns, reflectors, refractors, diffusing glassware, etc., to ensure that the most efficient and the best suited fitting shall be installed in the streets, and so we have the necessary data to assure us that our light sources are not only placed to the best advantage, but that the best use is being made of them. A recent example was the many weeks of laboratory tests preceding the erection of an installation comprising twenty units of the new gaseous discharge lamps. These tests of various lamps, chokes, lanterns, etc., ensured that the practical tests on the streets started with every advantage.

It is interesting to note that we have an arrangement in Glasgow with the local Technical College to work with this Department in testing various articles. When the question of a cube integrator was considered, our requirements would have been best met by possessing both a 1-metre and a 2-metre cube. Eventually both will be secured, but in the meantime we have the 2-metre cube, and our smaller units are tested in the 1-metre cube belonging to the College.

The head of the test room staff looks over the stores day book each day and notes incoming materials to be passed by him. This list will include mantles, cable, glassware, burners, gas and electric fittings, electric lanterns, paints, and oils. If the first item alone is taken a very substantial sum can be lost annually through the falling off in quality from such standards as have been stipulated in contract. The mantles we use in Glasgow are of three

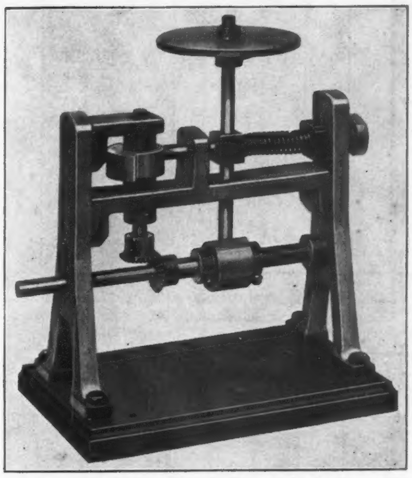


Figure 14. Gas Mantle Shocking Machine.

sizes and are shown herewith (Fig. 13). A shocking machine on the lines of that illustrated (Fig. 14) is used as a preliminary test, and our minimum requirements in shocks are, for No. 1, 300; No. 2, 600; No. 3, 3,000. We insist, therefore, that the quality of stock deliveries shall be maintained, but the fairness of our methods are recognised, and if a batch of mantles are found to be under par, replacements are immediately made. Should the British Standards Institution have a specification for an article used by the Department it is adopted as standard.

Possessing a fairly well-equipped test-room with many years of experience, we have been able to draw up detailed specifications for the manufacture of many of our materials and fittings. An example of this is the specificaton we issue for electric lanterns, of which there are two sizes, one to take lamps of 150 and 200 watts, and the other, lamps from 300 to 1,500 watts. The smaller of these lanterns is mounted on our standard 28-ft. pole and the larger on our standard 37-ft. pole. Although by no means perfectly satisfied with this specification, we have a very serviceable lantern evolved from many years' experience. Naturally, we expect and insist on the lantern conforming to all the details of the specification we submit, but, nevertheless, we welcome suggestions from manufacturers of new or improved ideas, for we recognise that new ideas are the keynote to "Better Lighting Practice and Improved Equipment."

Removing Paint from Lamp Pillars.

An interesting item in the proceedings at Aberdeen was the account given by Alderman Shorrocks and Mr. Charles Worswick of a new process of removing paint from lamp-pillars, recently devised by Mr. J. H. Massey, of Oldham. (Some pillars were hidden by fifty to eighty years of repainting!) A local firm of decorators at first tried orthodox methods, involving a combination of blow-lamp, paint removers, and chipping. The cost was about £1 per pillar. A subsequent experiment with a pneumatic chipping process was less costly (12s. 6d. per pillar), but a minimum order for five hundred pillars was required.

Finally, as a result of the Corporation's own experiments, there was evolved a sectional furnace which completely enclosed the pillar, silicate of cotton instead of cotton-waste being used to hold the paraffin with a view to avoiding smoke. The paint is fried for six minutes. The pillar is then scraped and a second heating carbonises any final residue, which is easily removed with wire brushes. A priming coat of paint is then applied whilst the pillar is still warm. The whole process occupies two men forty-five minutes, and the cost of material is only 1s. 6d. per pillar, 1,500 pillars have already been thus treated.

APPENDIX I.

A 250 Division.

Despatch of Men to Light, Week Ending, ____________ *19* ______

DATE	STAIR LAMPLIGHTERS SQUADS.										SCALE TIME.	REMARKS.
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th		

Stair Lamplighters commence to light.................................minutes before Scale Time

" " " " extinguish.................................minutes after " "

DATE.	STREET LAMPLIGHTERS SQUADS.										SCALE TIME.	REMARKS.
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th		

Street Lamplighters commence to light.................................minutes before Scale Time

APPENDIX III.

ELECTRICIANS' (STREET) WORK.

G. C. L. D. 750

No. ____________ Division ____________

Situation of Job ____________

Complaint ____________

Date ____________ Attended to by ____________

Designation of Work ____________

MATERIAL USED.

Description	Quantity	Description	Quantity
Swan Necks........	....	Reflectors........	....
Tiles..............	....	Blocks...........	....
Cable, 3/20 Braided	....	Switches.........	....
" 7/20 Braided	....	Cement....lbs.	....
" 7/18 Braided	....	Sand........lbs.	....
" 3/20 C.T.S.	....	Plugs...........	....
" 3/20 S.W.A.	....	Lanterns........	....
" 7/20 S.W.A.	....	....	....
Tube, 1"	....	....	....
" 3/4"	....	....	....
ElectricLamps	....	....	....
Boards..........	....	....	....
Brackets........	....	....	....
Screws..........	....	....	....
Knees...........	....	....	....
Tees............	....	....	....
Nipples.........	....	....	....
Bends...........	....	....	....
Couplers........	....	....	....
Jam Nuts........	....	....	....
Aerial Wire......	....	....	....
Insulators......	....	....	....
J Boxes.........	....	....	....

APPENDIX VII.

BEAT SURVEY SHEET.

DIVISION...

BEAT No...................

193 .

Date	Scale Time		Despatched from Muster Hall	Lighting Beat		Extg. Beat		General Condition of Beat and Remarks	Surveyed by :—
	Ltg. p.m.	Extg. a.m.	p.m.	Start p.m.	Finish p.m.	Start a.m.	Finish a.m.		

APPENDIX II.

*R 24779

INCANDESCENT STAIRLIGHTING

Date,..............................*19*........ *Section,*.............................. *Division,*..............................

2879

No.	Street	Stair-case	Flat	Breakage or Defect	Work Done and Material Used					
					Mantle	Globe	Ring	Burner	Work done by	Remarks

APPENDIX IV.

BROKEN LANTERN PANES. 250

No. 2819 The undernoted panes are broken and require to be glazed:

Situation of Lamp	Size of Lantern	Lamps Broken

Date.............. Division.............. Signature..............

APPENDIX V.

Survey of Street Beat No..............**Division**..............**Date**..............**193**

Signature of Surveyor,

No 2877

Position of Lamp	Condition of			Time of Survey	Remarks
	Mantle	Light	Lantern		

13m/3/32

APPENDIX VI.

REPORT ON DEFAULTERS.

DIVISION.............. **Date,**..............**19**........

Defaulter's Name, Rank, Number and Rate of Pay,..............

....

....

Nature of previous Offences, with Dates,..............

....

....

Nature of present Offence and Report,..............

....

....

....

....

....

....

....

How dealt with,..............

....

....

Foreman's Signature,..............

1m/2730

THE ASSOCIATION OF PUBLIC LIGHTING ENGINEERS

Annual General Meeting

At the annual general meeting, which took place in the Music Hall at 10 a.m. on Wednesday, September 19, two pleasant incidents preceded the transaction of formal business.

MR. HAYDN T. HARRISON MADE AN HONORARY MEMBER.

After the minutes of the last meeting had, as customary, been taken as read, the President announced that the following telegram had been addressed to Lt.-Commander Haydn T. Harrison, whose absence through ill-health all present would regret:—"The President and Council of the Association of Public Lighting Engineers send good wishes and ask you to accept Honorary Membership."

The following telegraphic reply had been received: "Much appreciate honour conferred by you and Council.—Haydn T. Harrison."

He felt sure they would all endorse this recognition of Lt.-Commander Haydn T. Harrison's services to public lighting and the deep interest which he has always taken in the welfare of the Association.

PRESENTATION TO RETIRING PRESIDENT.

The second incident was the presentation to Mr. E. M. Severn of the Presidential Certificate and Badge of Office (awarded to past presidents at the expiration of their term of office). Mr. Alex Forbes, in making the presentation, thanked Mr. Severn warmly for all he had done on behalf of the Association.

THE ANNUAL REPORT.

The next step was the presentation by the Hon. Editor, Mr. E. J. Stewart, of the annual report.

Mr. J. F. Colquhoun commented upon the very comprehensive data assembled in the report, and drew attention to the tabular matter relating to various cities, which formed a new feature. He emphasised the duty of members to send in their contributions *early*, so that these records might be made as complete as possible.

Mr. F. X. Algar also congratulated Mr. Stewart on the admirable way in which he had prepared the report, which must have involved an enormous amount of work. It afforded evidence of steady progress by the Association. Mr. Algar concluded by moving the following resolution, which was seconded by Capt. W. J. Liberty and, on being put to the vote, was declared carried unanimously:—

"That the annual report for the year 1933-34 and the accounts for the year 1933 be hereby adopted, and that a cordial vote of thanks be extended to the President, Council, and Officers for their services during the past session."

After the President had briefly responded, a supplementary vote of thanks to the Hon. Secretary and his staff was moved by Mr. E. M. Severn, and was also carried with acclamation.

ELECTION OF OFFICERS AND COUNCIL.

The President explained that there had been only single nominations for the positions of officers, who had thus been automatically elected. He would, however, now present the report of the scrutineers, Mr. F. X. Algar and Mr. P. Richbell, which showed that Mr. J. F Colquhoun, Mr. H. V. Emptage, Mr. J. Sellars, and Mr. H. W. Gregory had been elected members of Council.

A vote of thanks to the scrutineers for their efforts was proposed by the President, seconded by Mr. T. Wilkie, and carried unanimously.

PLACE OF MEETING FOR 1935.

The President announced that the Council had decided upon London as their meeting place for 1935, an arrangement which should prove expedient in view of the fact that the president-elect (Mr. A. M. Bell) would be on the spot.

The concluding resolution: "That a cordial vote of thanks be extended to the Lord Provost, Magistrates, Town Council, and Gas and Electricity Departments of Aberdeen for their hospitality during the Association's visit to Aberdeen" was supported by Baillie Ritchie (Edinburgh) and Councillor Fasham (Margate), both of whom expressed their appreciation of the generous hospitality which the Association had received during their visit to this most interesting city.

Exhibition of Public Lamps and Lighting Equipment

We hope to deal more fully, in our next issue, with the Exhibition of Public Lamps and Lighting Equipment, staged in the Music Hall Buildings, Aberdeen, during the period of the Conference. The Exhibition was formally opened to members and delegates on the afternoon of Tuesday, September 18, and was visited by the public on the subsequent day, posters inviting their attendance having been previously displayed throughout the town and on public tramcars.

In a brief introductory address, the Hon. Secretary (Mr. J. S. Dow) recalled the statement made by the late Councillor Minshall at Blackpool two years ago to the effect that over £1,000,000 is spent annually on public lighting by eleven provincial cities alone. This illustrated the need for skill and care in the choice of lighting equipment and the desirability of public lighting engineers and chairmen of lighting committees keeping themselves informed of progress.

In dealing with the Exhibition Mr. Dow drew attention to the efforts to improve the efficiency of sources of light, using both gas and electricity, alluding especially to the electric discharge lamps which had come into use since the last exhibition was held. He mentioned especially three recent developments in electric discharge lamps, which were shown at the Exhibition: (1) the efforts made to secure a "whiter" light; (2) the introduction of lamps taking only 250 watts (instead of 400); and (3) the design of lanterns enabling the luminous tubes to be mounted horizontally—an arrangement which it was hoped would lead to better control of the light-flux than was possible with the tube in the usual vertical position.

Attention was drawn to recent work on brightness and visibility and to the effect of the nature of the road surface, which had influenced recent design. Makers of both gas and electric lighting units were introducing novel forms of directive equipment which modified the natural polar curve of light distribution. Some reference was also made to systems of distant control of gas lighting, and to devices to facilitate automatic lighting-up and extinction of public lamps. A supplementary exhibit of special interest to public lighting engineers was the model street, set up by the General Electric Co., Ltd., in the ante-room of the lecture theatre.

The firms taking part in this indoor exhibition were as follows: The Automatic Light Controlling Company, The British Thomson-Houston Co., Ltd., The Edison Swan Electric Co., Ltd., Engineering and Lighting Equipment Co., Ltd., Falk, Stadelmann and Co., Ltd., Foster and Pullen, Ltd., The General Electric Co., Ltd., Gowshall, Ltd., Holophane, Ltd., The Horstmann Gear Co., Ltd., Lighting Trades, Ltd., W. Parkinson and Co., Ltd., Radiovisor Parent, Ltd., Revo Electric, Ltd., Siemens Electric Lamps and Supplies, Ltd., The Simplex Electric Co., Ltd., William Sugg and Co., Ltd., Venner Time Switches, Ltd.

Road Surface Reflection Characteristics and their Influence on Street Lighting Practice

by J. M. WALDRAM, B.Sc., A.C.G.I., F.Inst.P.

(Communication from the Staff of the Research Laboratories of the General Electric Company, Ltd., Wembley, England)

Paper presented at the Eleventh Annual Meeting and Conference of the Association of Public Lighting Engineers, held in Aberdeen during September 17th to 20th, 1934.

SUMMARY.

This paper discusses the relation between the appearance of an illuminated road surface, the reflection properties of the surface, and the distribution of light from the light source and its position. The geometry of the system is examined and special methods are given for plotting a street in perspective, from the plan and similar data. New methods of photometry of the brightness of the street surface are described, and data are given of the reflection properties of a two-coat asphalt surface. Methods are given of predicting the brightness distribution over the surface when illuminated by a source having any given light distribution, and at any height and distance. The effects of considerations of brightness are discussed as regards the design of installations, the design of lighting equipment, and the desirable characteristics of road surfaces.

(1) INTRODUCTION.

Lord Kelvin, we are told, used to say that:

" When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of ' Science,' whatever the matter may be."

It is quite understandable, after such an observation, that some of those best qualified to speak about street lighting call it the " art of street lighting." For the real quality and essence of street lighting have persistently escaped measurement. Certainly, we measure what we can, such as the illumination on the road surface and the height of the posts, and sometimes achieve great complication thereby; but we have not measured the excellence of the installation. Our knowledge is of a meagre and unsatisfactory kind; street lighting is not yet a science.

The reason is that the criterion of excellence of an installation must be related to the appearance of the lighted street, using the word " appearance " in a broad sense; and it is a commonplace that the appearance of the street as the motorist or the Watch Committee finally sees it bears no recognisable relation to the installation as it was planned by the engineer, with the aid of an ordnance map and curves of intensity distribution.

Qualitatively, we know something about the problem. It will probably be generally agreed that the requirements of an effective system of street lighting is this, that the observer should feel confident of seeing clearly any object of material size up to a considerable distance, without any discomfort due to glare. It is also generally recognised and agreed that objects are seen on a street on practically every occasion by silhouette as dark objects against a bright background, and that the important matter in visibility and in good appearance is therefore the brightness of the surface. We know by experience that carefully-placed sources and certain distributions of light can be made to conspire with the peculiarities of some road surfaces to produce a high brightness with a fairly even distribution, against which anything can be seen, and to keep small the dark areas in which dangers may lurk unnoticed. We know that sources ought to be fairly high, and on the outside of curves; and we have various views about central suspension. But we have not yet been able to measure these things, nor express them in numbers; neither have we the data on which they can be designed from first principles.

The purpose of this paper is to explore quantitatively the connecting link between the street as planned and the street as seen, and to provide, if possible, some photometric measurement and geometric tools to enable the lighting engineer to predict more nearly the appearance of the installation. It should be emphasised at the outset that the paper is the record of a partly completed research, which has not yet progressed very far; and it will have no answer yet to a great many problems. Later work may modify its conclusions. It is hoped, however, that the discussion will bring both criticism and guidance for future work.

(2) THE TWO MAIN FACTORS.

Two factors are responsible for the difference between the street as planned and the street as seen. One, the reflection characteristics of the street surface, has been recognised for many years, and much has been written about it.† But although qualitatively many of the consequences of the peculiar properties of road surfaces are known, quantitative data is very meagre, and its application to design is very difficult.

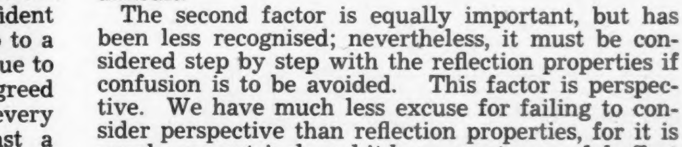


Figure 1. Iso-foot candle plan of an Installation.

The second factor is equally important, but has been less recognised; nevertheless, it must be considered step by step with the reflection properties if confusion is to be avoided. This factor is perspective. We have much less excuse for failing to consider perspective than reflection properties, for it is purely geometrical; and it has a most powerful effect upon the appearance of a road. It is intimately related to the surface reflection characteristics, and its consideration has led to a great deal of simplification of the problem. No excuse will, therefore, be offered for its discussion at some length, although it has been omitted from an over-long title.

Let us first consider an example of the effects of these two factors. Figure 1 is the iso-foot candle plan

† Preston Millar, Trans. Ill. Eng. Soc. (Amer.), 1910, p. 653; 1916, p. 479. Stewart, A.P.L.E., 1924. Waldram, A.P.L.E., 1928. Langlands, Proc. Municipal and County Engineers, 1932. Waldram, Roy. Soc. Arts J., February 9, 1934, p. 331.

of a section of roadway, determined by experiment. It may be taken as representing the street as planned. If now this section is drawn in perspective, as seen by a motorist opposite to the left-hand post in Figure 1, the appearance will be as shown in Figure 2. This indicates the peculiar effects which perspective produces. The first span occupies, in the perspective view, the region from the line, drawn across the road

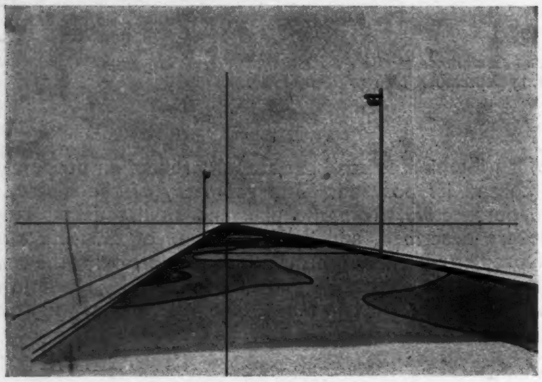


Figure 2. Iso-foot candle diagram in perspective projection.

by the first post, to infinity. The second span, however, although equally important on plan, occupies a space in the perspective as printed of only a sixteenth of an inch in height; and the whole of the rest of the road—supposing it to be level and straight—a further eighth of an inch in height. All the detail of the distribution in the second and further spans is cramped beyond recognition.

If now the effect of surface reflection is included in addition, the result is shown in Figure 3, which is from a photograph of the installation in question. (A slight hill has disturbed the simple perspective shown in Figure 2.) A comparison of the three figures will indicate the complete havoc which has been made of the plan of Figure 1 by the simultaneous operation of surface reflection and perspective.

Let us briefly note the general characteristics of the appearance of the road surface as shown in Figure 3 when lighted by a single unit. Where any notable degree of polish exists the brightness of the road surface beyond the post is very low, particularly when the road surface is dark in colour. In this region objects can be quite invisible, because they have a very dark background. But on the side nearer to the observer a bright patch or streak is formed, the centre line of which always runs directly towards the observer, and which extends over very long distances on the road surface. It often happens that a single source will produce a bright streak several hundred feet in length. Near the post the streak becomes wider and the complete streak often has the appearance of a T or inverted L.

These bright patches have not really a sharply defined edge, but where the brightness falls off to a low value they cease to form an effective background; and this limit is fairly easily seen.

The superimposition of several of these streaks forms the brightness distribution on the road surface; and it is with their formation, size, and position, that this paper is concerned.

Now the chief function of public lighting nowadays is to enable the vehicle driver to see the pedestrian and other objects in the carriageway, and the pedestrian to see the vehicles approaching him. Of these two individuals the driver is the more important, at least in so far as his requirements are the more difficult to meet; and the driver is particularly concerned with these long bright streaks. For a driver sees objects on a lighted road by silhouette against the bright surface,* and he generally drives looking at the road some 300 feet ahead. He is not usually very concerned with objects within the span in which he may be driving, although he is close to them; for having seen them some distance before, he has set his course and speed to avoid them, and is now concerned in weighing up the traffic about three spans ahead, in order to determine his further course and speed. If, therefore, he is to see objects 300 feet away, he will see them against the street surface at a greater distance, and that surface will appear bright only by reason of streaks formed by still more distant sources. Any source between the driver and the object cannot contribute to the background against which the object is seen. Therefore the contribution to the surface brightness made by sources 400 to 600 feet distant is a most important feature, and more important to the motorist than that from the nearest posts.*

On the other hand, the pedestrian, although concerned with a distant view of fast moving traffic, is much more concerned with near objects; and he requires illumination as such in the span in which he happens to be, in order to see the kerb, or obstructions, or the numbers of houses.

The streaks are formed as the result of the way in which the light is reflected from the road surface. If this were matt, its brightness would be the same in all directions of view. If it were polished as a mirror the incident light would leave the road surface only in directions defined by the laws of reflection, and the result would be a clear mirror image of the light source, lying apparently below the surface.

But the surfaces used in practice all possess some degree of partial polish: they are neither matt nor

Figure 3. Photograph of installation.

specular, but have intermediate properties which have been called "spread" reflection characteristics. Light leaves such surfaces mainly, but not entirely,

* Waldram, A.P.L.E., 1928. Preston Millar, I.E.S., 1928, p. 1051.

* Péri has suggested that the vision of a moving observer, such as a motorist, differs from that of a stationary observer in that he looks at a fixed distance ahead, and r is therefore constant (see paragraph 3 (b)). This is probably incorrect. Each sees the whole of the perspective in just the same way, though the motorist concentrates upon objects at about 300 feet away. In each case the gaze shifts from one point to another, and momentarily holds the image of that point steady on the retina.

M. D. Vernon, Med. Res. Council. Reports of Committee. "Physiology of Vision.—VIII." (H.M. Stationery Office.) Péri: l'Ellectrotecnica, 1928, p. 263.

in preferred directions not far from the direction in which specular reflection would take place.

As the observer views the street, those parts which reflect light in his direction appear bright, their brightness depending upon the amount of light falling upon them, and their preference for reflecting it in his particular direction. The peculiar shape of the streak is an index of the various degrees of preference which exist in different directions. For example, it runs directly towards the observer, because the surface prefers to reflect mostly in the plane of incidence, as a mirror: it is narrow because that preference is marked, and little light is reflected in other planes.

(3) GEOMETRICAL PROBLEMS.

Before the methods of measuring brightness and reflectivity can be described, it will be necessary to explore, as briefly as possible, some of the geometry of the appearance of the street.

(a) Perspective.

A perspective view is a geometrical projection with certain quite definite properties, which can be usefully turned to account. Let us, without going deeply into perspective geometry, observe a few of its characteristics.*

The construction of a perspective projection may be seen from Figure 4.

Figure 4.

Let ABCD be a solid object, and let P be the eye of an observer. If M is a plane, transparent, but capable of being drawn upon, and if the observer traces upon M the outline *abcd* of ABCD, each point

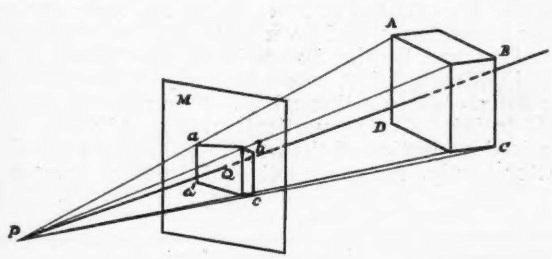


Figure 4.

on the trace being in line with his eye, and the corresponding point on the object, then *abcd* is a perspective projection of ABCD. In other words, *abcd* is a projection of ABCD upon the plane M by straight lines passing through P. A photograph is a perspective projection, the point P being in the lens of the camera. The line PQ through P and normal to M is the axis of perspective, and Q is the centre of perspective. The length PQ is the perspective distance, or, in the case of a photograph, the focal length of the camera lens.

Evidently, if a perspective projection of an object is made, and is viewed from the point P, from which it is drawn, then the view of the perspective will correspond in all geometrical respects with that of the original object: the angles subtended at the eye by parts of the perspective will be the same as those subtended by corresponding parts of the original object. A perspective properly represents the object as seen.

It is easy to show that:

(1) The perspective projection of any vertical straight line is a vertical straight line (if M is vertical), and the projection of any horizontal straight line *which is parallel to M* is a horizontal straight line; and

(2) The projection of any system of parallel straight lines, *not* parallel to M, is a series of straight lines converging to a point known as a vanishing point. If the series of lines is horizontal, the vanishing point will lie on a horizontal line through Q, and if the series of lines is parallel to PQ, then Q is the vanishing point. For instance, in Figure 5, the posts appear as vertical lines, and lines drawn across the road are horizontal lines; but the edges of the kerbs and paths appear as lines converging to the centre of perspective.

(3) A horizontal line on the surface of the road running directly towards the observer appears on the perspective as a vertical line.

It can also be shown easily that the scale of distances measured parallel to PQ is an inverse one:

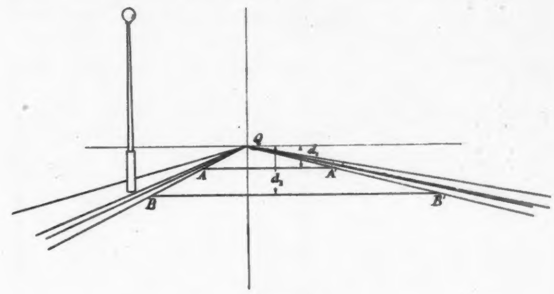


Figure 5.

e.g., in Figure 5 if A is the perspective projection of a point which is D feet from the observer, on the kerb of a road, then the intercept d_1, measured vertically, will be proportional to $\frac{1}{d}$. Along any line such as AA′, however (representing a line parallel to the plane of perspective M), the scale of distances in the projection is a linear one, although the scale at AA′ will be smaller than that at, say, BB′ in the ratio of d_1 to d_2 in the Figure.

It is also evidently quite easy to place upon a perspective chart a scale of angles, for the position of objects in the perspective is obviously defined by angles measured at the eye. A series of horizontal* and vertical lines can thus be placed on the perspective indicating angles of elevation or depression (d) and bearing (ϕ_2), so as to form a frame of reference for the perspective. (See Figure 6.) The distance of

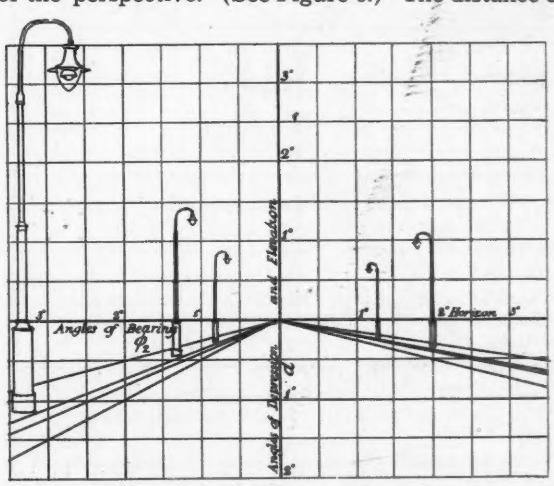


Figure 6. Angular Scales on Perspective.

a line representing an angle d or ϕ_2 from the axis is given by PQ tan d or PQ tan ϕ_2.

This means that any perspective view, such as a

* For further notes on the subject, see Waldram, P. J., and J. M., R.I.B.A. Jour., XL., Ser. III., No. 15, p. 609, June 17, 1933.
Waldram, P. J., R.I.B.A. Jour., XLI., p. 509, March 27, 1934.

* The lines indicating elevation are not strictly straight, but form a series of hyperbolae. Within the range dealt with in this paper, they can, however, be considered as straight and equally spaced, without serious error.

photograph, is in itself a record of angles of bearing and elevation of objects as seen from an observer's eye, or from the position of the camera.

The first requirement in designing an installation as it will be seen, rather than as generally planned, will be to portray it as it will be seen in perspective. The step from a plan to a perspective is really quite easy, and to facilitate the operation Figure 7 has been prepared.

This figure is simply the perspective view from a height of five feet (the average height of a driver's or a pedestrian's eye) of a web of lines drawn at right angles to one another on a horizontal plane passing through the observer's feet, which will be termed the reference plane. One set of lines, which is arranged along the general direction of the street and parallel to the direction of view, is at 1 foot spacing, and the other set consists of lines drawn at right angles to them at various convenient distances from the observer. There is also shown a vertical scale, which can be taken to be drawn on a post at a distance of 200 feet away and 10 feet left of the line of sight. The scale of height is also carried down below the reference plane. Although this scale is correct only for objects at 200 feet from the observer, it can be easily made to apply to any other distance, as will be shown. The scale of distances at right angles to the line of sight is marked on a line through the foot of the post, R, and is identical, on that line, with the scale of heights. On this web of lines the perspective view of the street can be plotted directly.

Suppose that a plan of the highway exists giving the kerbs, buildings, and proposed lighting fittings, and also particulars of levels, etc., as in Figure 29 (to appear later).

Suppose that a point of view has been chosen from experience, or otherwise, as one from which visibility is likely to be poor. Let a line of sight along the street be drawn, and let offsets be taken from this line to the edges of the kerbs and to any other point which it is required to plot. If the road is level, the perspective can at once be plotted on Figure 7 by these offsets.

If the road is not level, or if it is required to plot any other point, such as a light source, not on the level of the surface of the road, the procedure can best be followed by way of an example. Suppose we wish to plot a point on the kerb A, which is 300 feet from the observer, 8 feet left of the line of sight, and 2 feet below the plane of reference. The point is first plotted at A′ as though it were on the plane of reference, and a vertical line drawn through it. To correct for the change in height, a point, B, is found which is 2 feet below R, and at 8 feet left on the horizontal scale through R. This point is joined to Q to intersect the vertical through A′ at A, the required projection of the point. It is thus a simple matter to plot the perspective of quite a complex

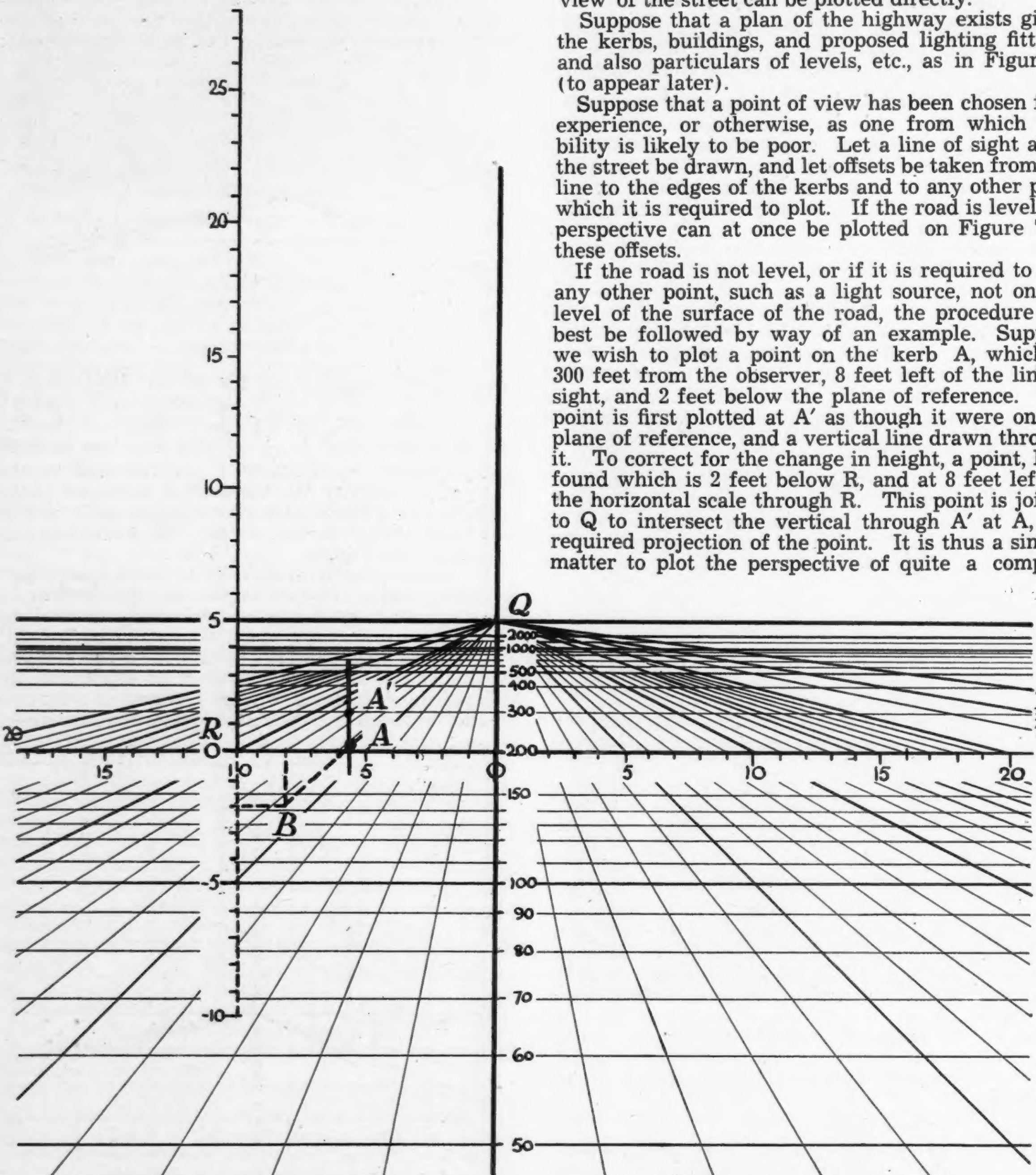


Figure 7. Perspective Plotting Web.
(Drawn for Perspective Distance of 88 cms.)

street from a given viewpoint. Figure 30 shows the perspective of Figure 29 as seen from P, Figure 29.

(b) Geometry of Installation.

Now let us consider the geometry of the formation of a "streak" in the perspective view.

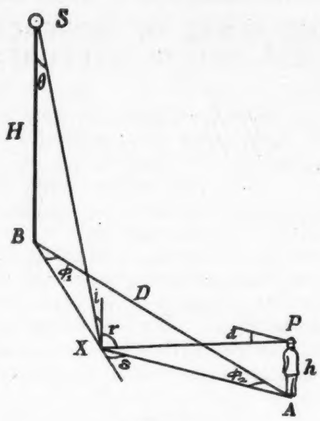


Figure 8.

In Figure 8, let S be the light source and P be the observer's eye. Let the distance of the observer from the post be D. Suppose that the observer is looking at a point X on the road surface, X being not on the line AB. Light will then be emitted from the lantern at S, fall upon X, and be reflected to P, the brightness of X being dependent upon the amount of light falling upon it from S, and the amount which the surface reflects in the direction of P.

Now the appearance of the street surface to the observer at P consists of a pattern of points, such as X, of different brightnesses, arranged at various positions in his field of view, which are defined by the angles d and ϕ_2 in the Figure. These angles are the angles of bearing and depression which are drawn on the perspective of Figure 6. If we can find the brightness of the surface for each value of d and ϕ_2, we know the appearance of the street.

Now let us consider the point on the road, X. The reflectivity at X will vary with the angle of incidence, i; the angle of reflection, r; and also with the angle of deviation, δ, since X is not on the line AB, and the incident and reflected rays are not in the same vertical plane.

Finally, the light reaching the point X from S will depend upon the light distribution of the lighting fitting, and will depend upon the two angles, θ and ϕ_1, which are the angles which are the basis of the polar distribution of the lighting fitting.

These seven angles are all related to one another by the geometry of the installation, and a great deal can be learned immediately from the relationships which exist between them. Let us consider first the angles measured in horizontal planes. Obviously, by simple geometry, $\delta = \phi_1 + \phi_2$ (Figure 9); and if X

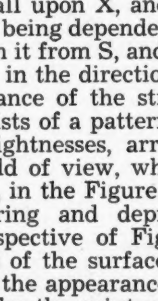


Figure 9.

moves on the road surface, so that δ is constant, it will move on a circle through A and B. In plan, lines of constant δ will be a series of such circles.

If, now, we plot these circles in perspective as they would appear to the observer, they will appear as in Figure 10. (The method of setting out these lines in perspective is given in the Appendix.)

Now it is evident, from observation of streets, that the reflectivity of the street surface varies very rapidly with the deviation δ, falling off rapidly as δ increases. This is the reason for the formation of the bright streaks which characterise the appearance of all polished road surfaces. The shape of the lines of equal δ in Figure 10 supports this observation, for they follow approximately the shape of the streak at least at its lower end. This is later confirmed by experimental results.

Now let us consider the angles measured in vertical planes. It is obvious, from Figure 8, that $\theta = i$; and $r = 90 - d$. That is, the vertical angle in the polar curve is equal to the angle of incidence on the street surface, and the angle of reflection from the street surface is equal to the complement of the angle of depression in the perspective. In fact, if in the perspective we measure d from the vertical instead of from the horizontal, the scale of d on the perspective will be a scale of r. It is so marked in Figure 10 at the side. Now there is obviously a relation between i and r, depending on the heights of the observer and the light sources and the distance D. This is easily shown to be

$$\tan i = \frac{D - h \tan r}{H} \qquad (1)$$

where h is the height of the observer and H that of the light source above the surface. If we plot the

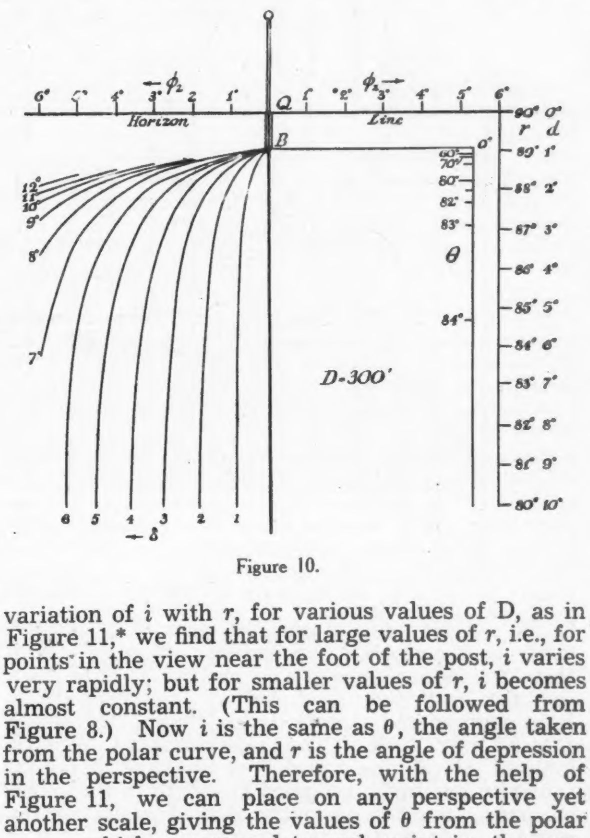


Figure 10.

variation of i with r, for various values of D, as in Figure 11,* we find that for large values of r, i.e., for points in the view near the foot of the post, i varies very rapidly; but for smaller values of r, i becomes almost constant. (This can be followed from Figure 8.) Now i is the same as θ, the angle taken from the polar curve, and r is the angle of depression in the perspective. Therefore, with the help of Figure 11, we can place on any perspective yet another scale, giving the values of θ from the polar curve, which correspond to each point in the perspective.

We now discover that for viewpoints at a reasonable distance from the source, the greater part of the field of view is served by a very small region of the polar distribution. At 200 feet distance, with a source height of 25 feet, almost the whole of the field

* In Figure 11, the angle of depression d has been plotted instead of r, for convenience; since this is equivalent to reversing the scale of r, the scale of i has been also reversed.

of view is served by the part of the polar curve from 75° to 82°. Figure 11 shows also that as the distance of the observer from the post increases, so the region of the polar curve which serves the major portion of the field of view becomes narrower, and lies at a greater angle with the vertical. The effective regions of the polar curve are as follows:—

Table I.

Distance from Post.	Effective Region of Polar Distribution.	
	Height of source, 25 feet.	Height of source, 13 feet.
200 feet.	75° —82°	81° —84°
300 „	82° —84½°	86° —87°
400 „	84½°—86½°	87° —88°
500 „	86° —87°	88° —88¼°

This indicates an important characteristic of the polar distribution. In some forms of street-lighting fitting the intensity is arranged to be cut off at about 78°-80°, or, at least, to diminish greatly in value, in order to reduce glare and increase efficiency. While this does reduce glare, it also has the effect of reducing the brightness produced by the more distant light sources and materially shortening the streaks which they form. The usefulness of intensity emitted above the "peak" or angle of maximum intensity has been discussed at length in the technical press,* and the geometry of the installation thus gives a large part of the answer.

The height of the post alters the relationship between i and r. It will be seen from equation (1) that a variation in H produces an inverse change in the tangent of i. Therefore, if, as in Figure 11, we use for the scale of i a scale of logarithmic tangents, and if this scale is movable along its length against a logarithmic scale of heights, then the i/r relationships, which were plotted for a height of 25 feet, can be made to apply to any mounting height. The height of the observer is retained constant at 5 feet from the ground.

This diagram relates, strictly, only to the line joining the observer and the light source, but since we shall be concerned only with small values of δ—say, up to 8°—it can be applied without material error to points on the road surface not on this line.

(4) MEASUREMENTS OF SURFACE BRIGHTNESS AND REFLECTIVITY.

(a) General.

Geometrical considerations can take us only a certain distance, and really form only the starting-point for experimental work. Before we can get any further we must know how bright any given spot on the road will appear under given geometrical conditions and values of illumination.

Several attempts have been made to determine the reflectivity of road-surfacing materials. Péri* made measurements of brightness on three types of road surface, both wet and dry, but his measurements were confined to the centre line of a road lighted by central suspension, in which all the streaks are superimposed. Preston Millar†, in 1928, made certain road-brightness measurements with a photometer having a restricted field, and published photographs having isolated brightness measurements marked on them; also brightness measurements in actual streets made with a constant value of r. A more thorough exploration was made by Taylor‡ at the National Physical Laboratory, using slabs of material taken from actual roads, illuminated by a large lamp, and viewed with a Macbeth photometer at various angles. These data are much more complete, but apply only to the centre line of the streak, where $\delta = 0$. At the present time work is being carried out by Cohu at the Société pour le Perfectionnement de l'Eclairage§, using the same general method, but much more

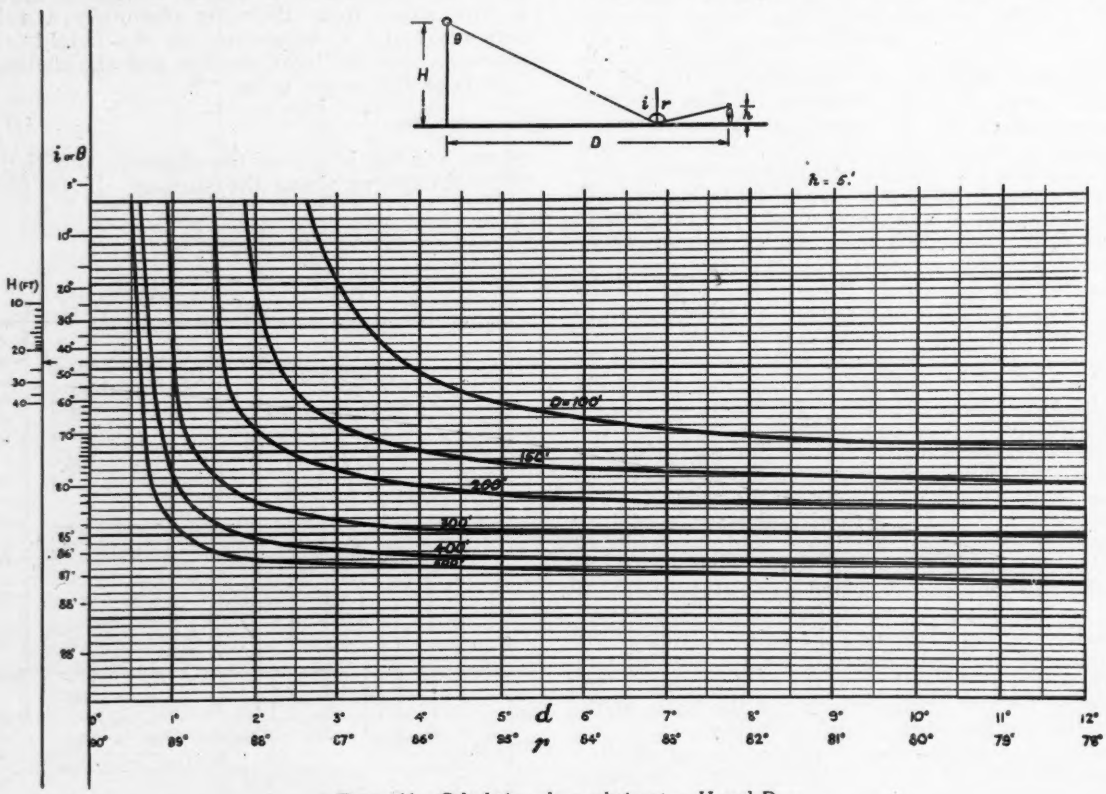


Figure 11. Calculating chart relating i, r, H and D.

* Ill. Eng., Dec., 1933, pp. 315-6.

* l'Ellectrotecnica, 1928, p. 263.
† Ill. Eng. Soc. Trans. (Amer.), 1928, p. 1051.
‡ I.C.I., 1928, Comptes Rendus, p. 49. D.S.I.R. Illum. Res. Cttee., Tech. Paper No. 9.
§ Revue Générale de l'Electricité, XXXV., pp. 147-155, Feb. 3, 1934.

elaborate apparatus, and using a photoelectric cell as the photometric element. This work will include measurements made at oblique angles.

M. Cohu's apparatus is necessarily large and costly, and involves the use of a large room. But not the least part of such experimental work is the portrayal and use of the results. It has been seen that the reflectivity of the surface varies with each of the three angles, i, r, and δ; so that a complete statement of the properties of any surface must require a family of solid polar curves, like iso-candle curves, or their equivalent. Having obtained these curves, their use in a given problem is not less complex unless the geometry of the problem is very thoroughly grasped; and simplification is not easy.

For two reasons—cost and complication—the measurements which are to be described have followed a different line. Methods have been devised of measuring reflectivity *in situ* from the light of an existing installation, and of so handling the results that they can be fairly easily interpreted and used.

The method is based upon Figure 11. Any point on this diagram corresponds to some particular values of i and r, so that (neglecting δ for a moment), it is possible to plot on this diagram a series of contour lines, joining points at which the reflectivity ρ is the same. If such contours are drawn on tracing paper and laid over Figure 10, with the scale of i corresponding to that on the slide in Figure 11, then the curves of Figure 11 will pick out from the contours the values of ρ appropriate to a source of any given mounting height, as determined by the setting of the slide, at a distance D corresponding to the particular curve used. One sheet can be prepared for each relevant value of δ, and if a perspective view is prepared for the given viewpoint, showing the δ lines (*see* Appendix), the values of brightness can be calculated and plotted along the δ lines on the perspective.

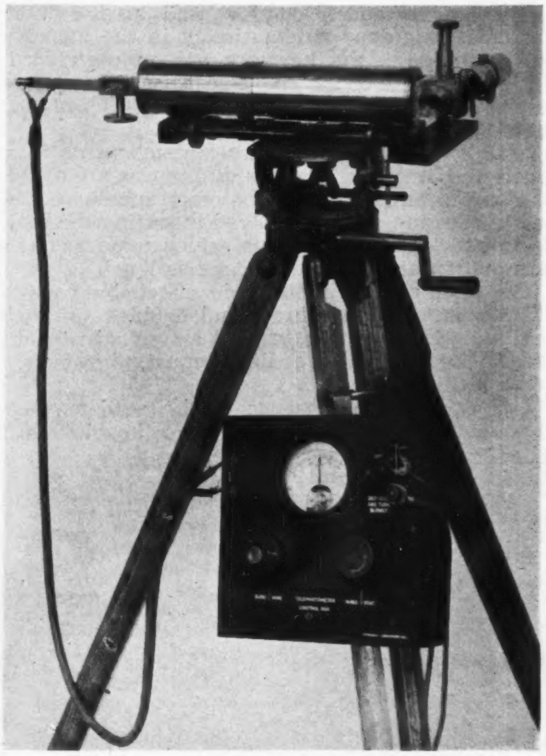


Figure 12. Telephotometer.

From this the complete brightness distribution in the perspective view can be built up. (See Figures 20-24.)

In order to obtain the data, it is sufficient to determine the reflectivity, for each point on the road surface, when viewed at the distances corresponding to the curves of Figure 10, viz., 100′, 150′, 200′, 300′, 400′, and 500′. Each of these determinations enables points of known reflectivity to be marked along one of the curves, and from the whole set of six determinations the family of contours can be plotted.

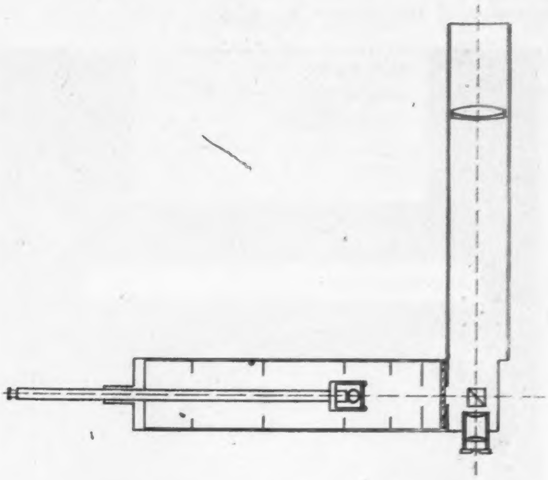


Figure 13. Optical elements of Telephotometer (Diagrammatic).

(b) Experimental Methods.

(i) *Telephotometer.*

The necessary experimental work consists in setting up, at the known distance from a single source, and at a height of 5 feet, an instrument capable of measuring the road surface brightness, and determining the brightness at a sufficient number of points at each station, in the same general way as that adopted by Millar and by Péri. Measurement must also be made of illumination in order to calculate the reflectivity.

The first instrument used for this purpose was a telephotometer (Figures 12 and 13) built for the purpose. This instrument was designed originally for use in models, and consists of a small telescope with a magnification of about 10, having a very small prismatic photometer field at its focus. The observer sees a telescope image of the street surface, in which appears a small rectangle having a central horizontal slit. This rectangle is illuminated to a known brightness by a photometer system similar to that of the Macbeth photometer, and a balance is obtained when the brightness of the road seen through the slit is equal to that of the surrounding rectangle. The angular width of the slit is about 1½ minutes of arc, and the actual size of the patch of silvering which constitutes the rectangle is about ¾ mm. x ½ mm. Making this field is a rather delicate operation.

The instrument is carried on a tripod having slow motion adjustments. It is believed to be one of the smallest telephotometers so far produced, and the only one suitable for model work. The writer hopes to publish a fuller description elsewhere.

(ii) *Photographic Method.*

While the telephotometer is excellent for the measurement of brightness at a few positions, for the purpose considered its use is lengthy and tiring. The obtaining of the data required by the above method with the telephotometer would need several complete nights' work on the road, and, moreover, involves several experimental inconveniences, not least of which is the measurement of the angles concerned. In the course of the work another method suggested itself, which has proved much more convenient, and agrees well with results obtained with

the telephotometer. Reference has already been made to the value of the perspective, inasmuch as it is possible to obtain from it all the angles concerned. The most straightforward method of obtaining a perspective is to take a photograph. If the photograph can be made to produce a quantitative measure of brightness as well, a much more convenient record is available of the surface brightness of the street. Experience has led most street-lighting engineers to disbelieve all photographs of installations except their own. It may come as a welcome surprise, therefore, to hear that a street-lighting photograph has, it may be for the first time on record, been made to tell the truth.

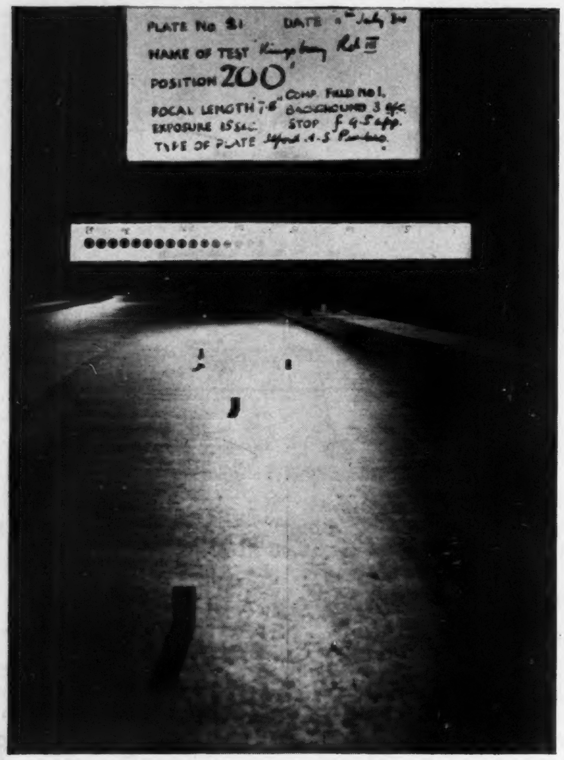


Figure 14. Typical photograph.

It is hoped that the method may be described in more detail on another occasion, when more results are available, but it is, briefly, as follows:—

A camera is set up at the appropriate position and a photograph taken of the street surface only. The part of the plate on which the image of the light sources would fall is covered, and the sources themselves are screened so that no direct light from them falls on the lens. All trouble from lens flare and halation is thus avoided. Afterwards, in the laboratory, the cover over the lower part of the plate is removed, and a photograph is taken on the same plate with the same camera, exposure and stop, using only the lower part of the plate which was previously covered, of a series of spots of known brightness, together with particulars of the plate for reference. The comparison spots are illuminated by light of the same type as that used in the street. The plate is carefully developed under standardised conditions, but development does not affect the results so long as it is even over the surface of the plate. Knowing the brightness of the spots photographed as a comparison, the brightness corresponding to each value of density in the plate can be found, and consequently the brightness corresponding to each part of the image can be determined. Figure 14 shows a print from a typical plate. (Measurements are made, of course, on the actual plate, not on a print.)

It was fortunate that there was available a Moll recording microphotometer, used for the densitometry of spectrograms, which proved ideal for the determination of densities. In this instrument the plate is moved slowly in a carriage, and a very small beam of light passed through it. After passing through the plate the beam is focussed upon a thermopile, the output of which operates a galvanometer. This records its deflection upon bromide paper carried on a drum geared to the plate carriage. A typical record is shown in Figure 15, on which is the record of a comparison strip and of two traverses taken across the plate.

The deflection of the galvanometer is measured on the record for each spot of the comparison strip, and a calibration curve for the record is thereby obtained. The brightness corresponding to any point on the record is thus obtained directly from the calibration curve.

It will be seen that this method* avoids most of the troubles inherent in photographic photometry, in that the results are independent of the law of the plate, time and temperature of development, absolute values of density, or the calibration of the Moll microphotometer.

In addition, it has the following great practical advantages.

1. The field work can be accomplished comparatively quickly and in comfort, and all the tedious photometry is done automatically in the laboratory during the day. Furthermore, a complete record of the whole surface of the street is preserved, and further photometry can be done on the plates if required.

2. Difficulties of brightness measurements at low levels and at difficult colour differences are avoided. The only heterochromatic photometric balance which has to be made is that involved in setting the brightness of the comparison spots, which requires one determination at about 3 foot-candles level.

The photographic method, in effect, increases the brightness to be measured, and enables quite low brightnesses to be measured at a conveniently high level. Illumination readings must, however, be made in the street.

3. The actual appearance of the road surface is very mottled, as can be seen from the photograph, owing to slight irregularities. This makes photometry with a telephotometer a matter of some difficulty, for it is not easy to obtain a mean reading, although an improvement results if the telescope is

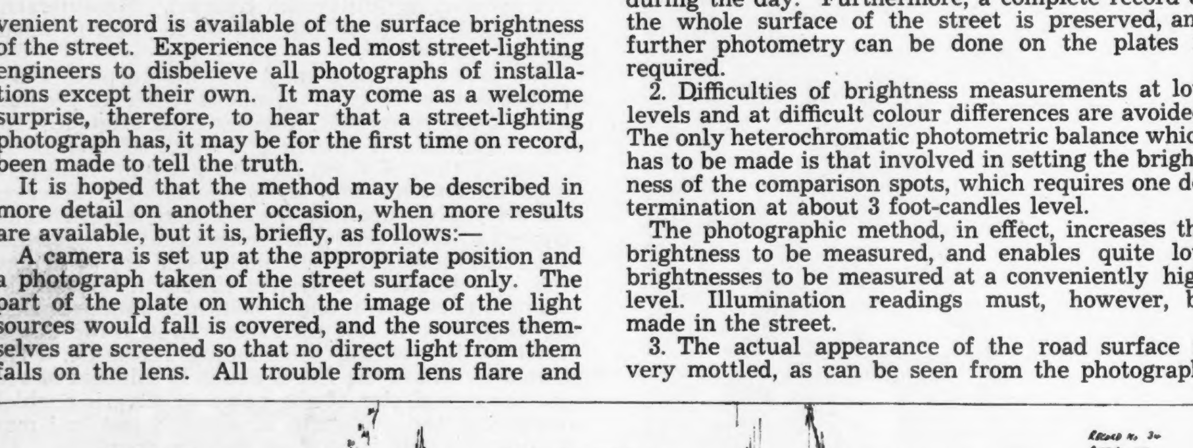


Figure 15. Typical microphotometer record.

* The method was obtained from "Photographic Photometry" (Dobson, Griffiths, and Richardson, Oxford, 1926), together with many practical details.

used slightly out of focus. The Moll record, however, shows exactly the nature of the irregularities, and enables a mean line to be drawn though the oscillations which appear on the record. This enables the results to be faired at an early stage, and helps to avoid inconsistencies.

The plate must be evenly developed; this was accomplished either by swabbing during the whole period of development, or by the use of a special tank, as described in the reference quoted above.

Tests showed the method to be in good agreement with results obtained with an illuminometer. When the photograph is taken on the road, certain reference marks are left to appear in the photograph, at which also illumination measurements are made, and an electric torch is placed on the surface of the road, under the fitting, in order to provide a zero mark.

(iii) Illumination Measurements.

Illumination measurements are made with a precision illuminometer, on a test plate arranged normal to the incident light, at a sufficient number of positions to enable illuminations to be calculated for the remainder of the required positions. This avoids measurements of very low values, and errors due to the test plate.

(To be continued.)

Comparison of the Revealing Powers of White and Coloured Headlight Beams in Fog

By W. S. STILES, Ph.D. (The National Physical Laboratory)

A Brief Description of the Experiments and a Statement of the Main Conclusion

The experiments were made on foggy nights in the winter, 1933-34. Two headlights of known candle-power distribution were mounted at the height and spacing employed on the average car, and were arranged to throw their beams parallel to and in the direction of the road (Kelvin-avenue, N.P.L. Grounds). An observer stood behind the offside headlight and viewed a test object consisting of a wooden disc painted grey and mounted on an upright so that the disc centre lay on the axis of the offside headlight. Test discs of different reflection factor were used on different occasions. With the aid of an assistant, who moved the disc up and down the road, the distance away y was determined, at which the observer could just see the disc. The experiment was repeated with the observer viewing the field through either coloured or neutral light-filters held in a binocular frame mounted on an upright at the appropriate height.

The aim of the experiments was to discover:—

(1) Whether the interposition of the colour-filters increased, decreased, or left unchanged the range y;

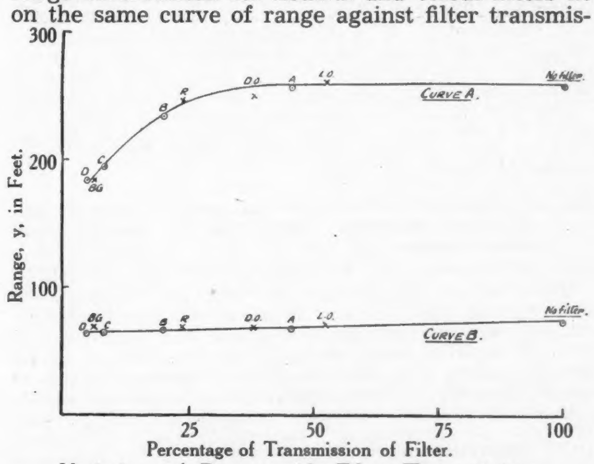
(2) Whether any change in range due to the colour-filters arose merely by reduction in the light intensities as seen by the observer. This question could be answered by comparing the ranges obtained with colour and neutral filters of known visual transmission.

The filters used were as follows:—

Colour filters.	Transmission for white light.	Neutral filters.	Transmission for white light.
Light orange (L.O.)	52 p.c.	A	45 p.c.
Dark orange (D.O.)	38 p.c.	B	20 p.c.
Red (R.)	24 p.c.	C	8.2 p.c.
Blue green (B.G.)	6.0 p.c.	D	4.6 p.c.

The results were represented by plotting the observed range y against the filter transmission. The character of the results differed somewhat for thin and thick fog. Two examples are shown in the Figure, one set being obtained in a thick fog, the other in a slight mist. The sets of data shown are among the best obtained. Other sets are more erratic owing to fluctuations of the fog during the observations.

The results, taken as a whole, point definitely to the conclusion that the sole effect of the colour-filters on range is due to the reduction in light intensity. This is established by the fact that the range observations for neutral and colour-filters fit on the same curve of range against filter transmis-



Variation of Range with Filter Transmission.

Curve A.—Test Disc No. 5 of Reflection Factor 0.08. Fog Transmission: about 80% in 100 ft.

Curve B.—Test Disc No. 4 of Reflection Factor 0.39. Fog Transmission: about 0.5% in 100ft.

sion. Such effect as occurs is always a reduction in range compared with the unmodified beam. In thick fog, the reduction in range, even for the 4.6 per cent. transmisisin filter, is small (see Curve B). For very thin fog a more marked reduction in range for the lower transmission filters was observed (see Curve A).

To sum up, as far as the determination of headlight range in fog by the present method enables us to judge, the revealing power of a coloured beam is the same as that of a white beam of the same intensity.

Although this represents the unambiguous conclusion of the experiments, the possibility cannot be excluded that for some special type of fog, not met with in the measurements, the result as stated may no longer hold good.

Literature on Lighting

(Abstracts of Recent Articles on Illumination and Photometry in the Technical Press)

(Continued from page 272, September, 1934)

I.—RADIATION AND GENERAL PHYSICS.

243. Normal and Abnormal Colour Vision.

H. E. Roaf, Nature, 134 *pp.* 442-445, *September* 22, 1934.

Gives a short and lucid account of colour vision and of the theories concerning its origin. The author expresses his own belief in the trichromatic theory of colour vision, and develops his own views upon this theory, namely, that there are three different kinds of receptors in the eye, viz., the rods and two types of cones. The rods are sensitive throughout the whole visual range, but with a preference towards the blue-violet end of the spectrum, and produce a "blue-violet" sensation. The cones of the first type are sensitive to a considerable range of the visual spectrum, but with, perhaps, a minimum sensitivity at the blue end, and produce the "not blue" sensation of the colour-blind person who cannot distinguish red from green. The cones of the second kind are sensitive to most of the visual range, with a marked preference to the red end, and produce the "red" sensation. A deficiency in the number of cones of this second type is supposed to cause colour-blindness. T. H. H.

II.—PHOTOMETRY.

244. Electric and Photometric Units.

Nature, 134, *p.* 239, *September* 1, 1934.

Vol. 15 of the Procès-Verbaux of the Comité International des Poids et Mesures is stated to contain the report for 1933 of the Advisory Committee on Electricity and Photometry. It is recommended that the primary unit of candle power shall be ultimately based on the radiation from a perfectly black body. The Advisory Committee hold the opinion that photometry of coloured lights can only be adequately secured by fixing "a priori" a curve of visibility throughout the spectrum, such as that recommended by the International Committee of Lighting in 1924. T. H. H.

245. An additive method for the precise study of the relation between photo-electric current and illumination.

P. Fleury, C.R., No. 3, *pp.* 195-197, *July* 16, 1934.

The author describes an accurate method of determining the relation between the photo-electric current and the illumination incident on a photo-electric cell. A parallel beam of light, the intensity of which can be varied, is divided into two component beams of equal intensity. These component beams are subsequently recombined before entering the cell. The method consists in measuring the photo-electric current, first, when the cell is illuminated by each component beam in turn, and then by both beams simultaneously. L. J. C.

246. The Skymeter; an instrument for the rapid determination of sill-ratios.

A. S. E. Ackermann, J. Sci. Inst., XI., p. 287, *September*, 1934.

This is a simple instrument, which permits of the outline of the sky seen through a fixed eye-hole being drawn on a flat sheet of glass, from which it can be traced on to paper and its area measured. From this area, the angle of elevation of the centre of the mass of sky and an apparatus constant, the sill-ratio is calculated. Test readings show that the apparatus is sufficiently accurate for its purpose. S. E.

247. The Arrangement of a Modern Illumination Laboratory at the Höheren Technischen Statslehranstalten at Bremen.

Meyer. Licht u. Lampe, 23, *No.* 14, *p.* 329, *July* 5, 1934; *No.* 16, *p.* 366, *August* 2, 1934.

A description is given of the arrangement of the laboratory and the apparatus installed. The space is divided into two parts, one for the general illumination measurements and one for photometry. The walls of the latter are painted brown instead of the more usual black. E. S. B-S.

248. The Stiles-Crawford Effect and its importance in Photometry.

W. Dziobek, Das Licht, 8, *p.* 150, *August*, 1934.

A summary of the work described by Stiles and Crawford in their paper, "The Luminous efficiency of rays entering the eye pupil at different points." (Proc Roy. Soc., B., Vol. 112, 1933.) S. E.

III.—SOURCES OF LIGHT.

249. Light.

E.O.T. Elect., 113, *p.* 274, *August* 31, 1934; *p.* 303, *September* 7, 1934; *p.* 335, *September* 14, 1934.

A series of articles dealing with the phenomena of light production, including energy, radiation, and eye sensitivity. Particular reference is made to sodium vapour discharge lamps and incandescent lamps. C. A. M.

250. Incandescence—Some Theoretical Aspects.

Samuel G. Hibben. Elect. Engineering, 53, *pp.* 1201-1204, *August*, 1934.

Some theoretical considerations involved in incandescent phenomena, with particular reference to incandescent illumination, are discussed in this paper. The author distinguishes between incandescent and luminescent radiation, and describes black body radiation and incandescence. The radiation from carbon and tungsten filaments is considered, and the advance of these as sources of light. S. S. B.

251. The Treatment of Air for the Extraction of Krypton and Xenon and on the Application of these Gases to Incandescent Lamps.

G. Claude. R.G.E., 36, *pp.* 237-240, *August* 18, 1934.

The author claims that Krypton and Xenon can now be extracted in quantity from the air, and that these gases have advantages over argon for use in incandescent lamps. W. R. S.

252. Characteristics and Uses of the Carbon Arc.

W. C. Kalb. Elect. Engineering, 53, *pp.* 1173-1179, *August*, 1934.

Characteristics of the various types of carbon arcs and their applications are outlined in this paper. The spectral composition of the light and the intrinsic brightness of the various sources are given. S. S. B.

253. Low Pressure Gaseous Discharge Lamps. Part 1.

Saul Dushman. Elect. Engineering, 53, *pp.* 1204-1212, *August*, 1934.

Radiation and conduction phenomena in low pressure gaseous discharge lamps are discussed in this paper. Results of measurements on the variables in a discharge are given, and an attempt is made to correlate them with the concentration of atoms at different energy levels, and with the luminous efficiency. An insight into the fundamental processes which occur in a gas discharge and govern the production of light in low pressure discharges is given. S. S. B.

254. The New Osram Mercury Vapour Discharge Lamp.

Licht u. Lampe, 23, *No.* 15, *p.* 352, *July* 19, 1934.

Details are given of the construction and operation of the new HgH type lamp. The lamp has an efficiency of 36 Lm/W., which includes the choke loss. It is fitted with an ordinary screw cap and is made for use on a 220 volt a.c. supply. E. S. B-S.

IV.—LIGHTING EQUIPMENT.

255. Modern Architectural Uses of Glass.

G. Lovell, J.S.G.T., XVIII., p. 106, 1934.

This paper deals with various uses of flat and bent glass, including surface treatments of different kinds, and their application as a decorative medium. The interiors and exteriors of buildings are discussed as well as methods of illumination. Special reference is made to "non-reflecting" windows. S. E.

256. Aluminium as a Decorative Medium.
Ideal Kinema and Studio, II., p. 11, September 13, 1934.

A description of the part played by aluminium and alloys thereof in modern decorative schemes. Illustrations of interiors of kinema theatres, showing their use in connection with lighting effects are presented. J. S. D.

257. Evaporated Metal Mirrors.
R. C. Williams, Nature, 134, p. 329, September 1, 1934.

It is advantageous in making mirrors by evaporation to evaporate on to the glass first a thin film of chromium and then a layer of aluminium. The film is at first fairly soft, but it is hardened by washing it in water or alcohol, and may then be rubbed hard with cotton cloth without appreciable change. Even rubbing with steel wool affects the film only slightly. The reflectivity of the films is similar to that of pure aluminium. The aluminium may be dissolved off without affecting the chromium. T. H. H.

258. Guard Saves Street Lights.
Anon. El. World, 104, p. 163, August 4, 1934.

A description and photograph are given of a cast aluminium guard for street lights, to protect the lamp from breakage. It is claimed that parts of the guard act as reflectors and increase the illumination on the road. S. S. B.

V.—APPLICATIONS OF LIGHT.

259. Motor Lighting.
F. Born, Das Licht, 8, p. 141, August, 1934.

The general inspector of roads in Germany has set out the following requirements for motor lighting: (1) The lighting equipment should provide an unbroken view of the roadway on the straight and on curves to a distance of 200 metres, and (2) screening on cars meeting should not be necessary; the lighting of one car must therefore not cause glare to an approaching driver. The necessary candle powers and light distribution curves from head lamps to meet these conditions are discussed. S. E.

260. Street Lighting.
L. Lecornu. C.R., No. 14, p. 1284, April, 1934.

For street lighting purposes, lighting fittings employing a source of light and a reflecting mirror are often used. The distribution of the reflected light depends on the position and shape of the mirror; for any desired distribution these two factors must be determined. By limiting the theoretical discussion to the case of a point source the author indicates how a general mathematical solution can be derived for any beam distribution. L. J. C.

261. Street Lighting Demonstrations.
P. Brune. Lux, VII., p. 91, July-August, 1934.

An illustrated description of experimental street lighting with mercury and sodium vapour electric discharge lamps and also incandescent (filament) lamps in the forest of Vincennes (adjacent to Paris). J. S. D.

262. Modern Types of Street Lighting with Gas.
Scholz-Frick. Licht u. Lampe, 23, No. 15, p. 348, July 19, 1934.

A brief description of the development of gas street lighting units with some details of their most recent form is given. E. S. B-S.

263. Mercury Vapour Lamps in Display Lighting.
A. Brauer, Das Licht, 9, p. 170, September, 1934.

Some details of a mercury vapour lamp installation for flood-lighting an advertising sign are given, together with the comparative costs using various kinds of lamps. Filament lamp installation costs are less. and sodium lamp costs greater than the mercury lamp costs. S. E.

264. The Century of Progress Stimulates Lighting Business.
Anon. Light, 3, No. 5, pp. 27-32, Second Summer Issue, 1934

Current American lighting practice, stimulated by the Chicago Exhibition, is indicated by a collection of photographs of recent shop lighting and other installations. C. A. M.

265. What the States Require in Industrial Lighting.
E. J. Poor. El. World, 104, pp. 135-136, August 4, 1934.

The article is a report on the investigation of industrial lighting conditions in the various States of America, and an examination of State lighting codes. S. S. B.

266. Factory Lighting.
Anon. World Power, 22, p. 126, September, 1934.

Some examples of progress in factory lighting, extracted from the Annual Report of the Chief Inspector of Factories and Workshops, are discussed in detail. C. A. M.

267. Arcade Lighting.
Anon. El. Times, 86, p. 226, August 23, 1934.

A brief description, with photographs, of the lighting of the Royal Arcade, Piccadilly, London. W. P. S.

268. The Salon of Decorator-Artists.
B. H. Martin. B.I.P., VII., p. 114, July, 1934.

An illustrated review of the above exhibition. Examples of highly original indirect lighting are shown. J. S. D.

269. Floodlight Study Finds Closed Units Economical.
Anon. El. World, 104, p. 151, August 4, 1934.

It is reported that the Union Oil Company, after a series of competitive tests, has standardised on the use of enclosed floodlights for its service stations. Photographs of one of their stations, with open and enclosed types, are shown. S. S. B.

270. Floodlighting by Gas.
Gas World, p. 199, September 1, 1934.

Illustrations and descriptions are given of the floodlighting of Gwyn Hall, Neath, during the Welsh National Eisteddfod. Particulars and illustrations are also given of the floodlighting of the Bilston annual flower show this month. J. G. C.

271. Floodlighting by Gas.
American Gas Association Monthly, p. 302, September, 1934.

A description is given of the floodlighting of the yard and entrances of the McBride Street Service Station by the Boston Consolidated Gas Company, the lamps used for the purpose being imported from England. J. G. C.

272. Under-water Pool Lighting Brings Several Innovations.
James Farrant and F. J. Greenley. El. World, 104, pp. 176-177, August 11, 1934.

A full description is given in this article of an installation, involving 60 k.w., for the lighting of an outdoor swimming bath. Of this, 50 k.w. is used for underwater floodlighting. S. S. B.

273. Lighting Service Bureau.
Anon. Elect., 113, p. 333, September 14, 1934.

A description, with a photograph, is given of the latest improvement in general lighting equipment at the Lighting Service Bureau in Savoy Hill. C. A. M.

274. National Radio Exhibition.
Anon. Elect., 113, p. 237, August 24, 1934.

An outstanding feature in the lighting equipment at the National Radio Exhibition in London was an installation of cold cathode discharge tubing assembled around a large electric clock. At each hour gongs were struck, following the apparent movement of the figures outlined. A photograph is given. C. A. M.

275. Southend Carnival.
Anon. Elect., 113, p. 259, August 24, 1934; p. 314. September 7, 1934.

A brief description is given, with two photographs as examples, of decorative and display lighting at Southend. C. A. M.

276. Plants and Light.
E. Reinau, Das Licht, 9, p. 161, September, 1934.

After reviewing some previous work on this subject, results are given of the effect on the growth of plants of the following light sources. Neon tube (2 amp.), Sodium lamp (80 w.), Nitra filament lamp (200 w.), Vitalux (filament 500), Neon (glow. 30 w.). Judged by the weight of green foliage (cress), the two Neon lamps and the Sodium lamp showed increased growth. S. E.

277. Is it Easier to See by Coloured Light?
W. Arndt. Zeits f. Techn. Physik, 8, pp. 296-301, August, 1934.

It is pointed out that the question of "easier seeing" with coloured light cannot be answered in a few words. The author examines the effects of contrast, glare, nervous tension, visual accommodation and fatigue, and several other phenomena, comparative results being given for mercury, sodium, neon, and tungsten filament lamp radiations. W. R. S.

278. Methods for Determining Illumination from Extended Sources of Uniform Brightness.
J. Dourgnon. R.G.E., 36, pp. 227-236, August 18, 1934.

The problem is stated to be greatly simplified by the use of a method involving auxiliary equivalent sources. The spherical source and associated problems are also dealt with. W. R. S.

Recent Patents

(Abstracts of recent Patents on Illumination & Photometry.)

413703. "Improvements in or relating to Lamps for Street Illumination and like purposes."
Kempton, C. H. A. and Parsons, E. H. P. M., January 20, 1933.

This specification describes a gas lamp for street lighting comprising a casing and a number of parabolic trough reflectors constructed from sheet metal and supported upon brackets having a profile corresponding to the desired profile of the reflector. Each trough reflector may be provided with an inverted incandescent gas burner. The reflectors may be of stainless steel. A shield may be placed above the burner to serve as a diffusing screen to deflect downwards upward light from the burner.

413937. "Improvements in Reflectors for Lamps."
Dietrich, F. R., November 23, 1932, January 6, 1933, January 25, 1933 (Convention, Germany. One Complete Specification).

This specification describes a reflector for projecting a beam parallel to the axis and one or more beams, all of parallel rays, in directions divergent from the axis. The reflector has a rim with a portion of parabolic curvature off-set with respect to the main parabolic portion, both parabolic parts having a common focus. Two such rim portions, differently off-set, may be used. The curvatures of the off-set parts may be different from that of the main part.

413959. "Improvements in Luminous Electric Discharge Tubes."
The General Electric Company, Limited, December 31, 1932 (Convention, Germany).

This specification relates to a sodium vapour lamp containing a quantity of sodium so small that all or the greater part of it is evaporated at the working temperature. Mercury up to 10 per cent. of the quantity of sodium may also be included in the tube.

414062. "Improvement in Mirrors and Projectors."
Stevenson, C. A., and Stevenson, D. A., January 25, 1933.

In order to compensate for aberrations of a focusing mirror, silvered on the back, due to refraction by the glass, both surfaces of the glass deviate from true parabolas, but the thickness of the glass is uniform.

414,420. "Improvements in Miners' and Like Safety Lamps."
Hailwood, E. A., November 9, 1932 and November 28, 1932 (Cognate Provisionals).

This specification describes an adapter ring for safety lamps to be arranged between the oil vessel and upper part of the lamp, to ensure an adequate supply of air from the lower part of the lamp to the burner and dome. There are also divisional Applications Nos. 414,385, 414,386, and 414,418, all dated November 28, 1932. The first of these relates to safety lamps having an elongated wick tube, in which the dome is some distance above the oil vessel and describes constructions by which the dome is hinged to permit access to the wick or wick tube. The second describes the attachment of a solid plate reflector to the burner or dome within an inner glass combustion tube. The third describes a lamp in which an inner glass combustion tube is mounted upon a revolving platform inter-connected with the burner or dome to rotate therewith and ensure correct alignment of the parts.

414190. "Improvements in Miners' Electric Battery Lamps."
The Concordia Electric Safety Lamp Company, Limited, and Stretton, T., April 13, 1933.

This specification describes a construction of miners' safety battery lamp in which the positive poles are plungers disposed centrally of the lamp and projecting in opposite directions under the pressure of springs secured on either side of a base supporting part formed as a fuse. The plungers may be concentric with negative contact surfaces and insulated therefrom by a sleeve. A fuse of bobbin form may be connected between the ends of the springs of the positive plunger contacts. The glass may be constructed and arranged to fracture at a certain place and when so accidentally fractured to cause disconnection of the circuit.

414391. "Improvements in and Relating to Electric Discharge Lamps."
The British Thomson-Houston Company, Limited, February 1, 1932 (Convention, Germany).

This specification describes a high pressure discharge lamp containing, in addition to such metals as mercury, cadmium or zinc, a small quantity of sodium, the quantities being adjusted to produce substantially white light.

414,611. "Improvements in Luminous Sources formed by Electric Discharge Tubes."
The General Electric Company, Limited, March 15, 1933 (Convention, Germany).

This specification covers a light source comprising a low voltage tube, which is preferably of a high vapour pressure type, and a high voltage tube, which is preferably of the low pressure type. The low voltage tube may be connected in series with the high voltage tube and a high voltage transformer, or a starting electrode, energised at high voltage, may be incorporated in the low voltage tube. The heat of the low voltage tube raises the high voltage tube to the correct operating temperature.

414,733. "Improvements in or relating to Lighting Fittings."
The General Electric Company, Limited, and Christopher, J. G., February 10, 1933.

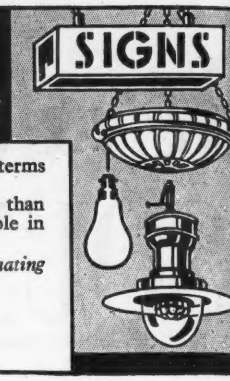
This specification describes a lamp in the form of a street bollard comprising a plurality of curved reflectors arranged louver fashion and a source of light within and at the top of the structure. In addition a reflecting surface may be located within the structure to direct to the reflectors light which would otherwise escape them. The light from the source travels downwards and is reflected horizontally outwards by the reflectors.

415,210. "Improvements relating to Lamp Reflectors."
Williams, A. E., April 26, 1933 (Addition to No. 395,611).

This specification relates to all-metal reflectors for use under great heat as in kinematograph projectors or in other adverse conditions and purports to provide a mirror of large diameter which will withstand such conditions. The mirror has a layer of nickel or cobalt of thickness at least 0.0004 inch, and a reflecting coating of a metal of the platinum group such as platinum, rhodium, ruthenium, or iridium.

·WHERE TO BUY·

A DIRECTORY OF LIGHTING EQUIPMENT



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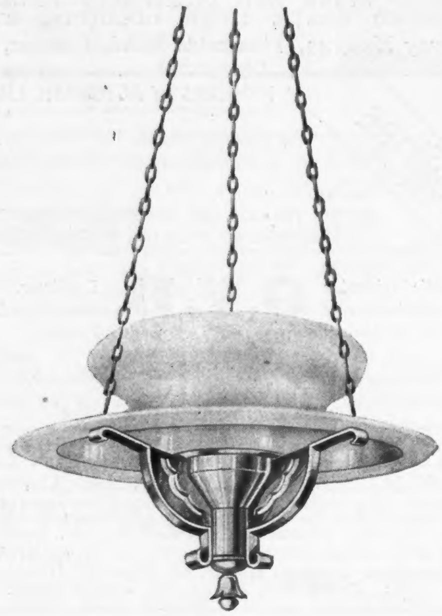
A New G.V.D. Fitting.

We show, in the accompanying illustration, a view of a new form of indirect lighting fitting introduced by G.V.D. Illuminators—new that is, in the sense that the general appearance has been greatly improved. This fitting was designed to furnish indirect lighting, with its attendant advantages in regard to soft shadow-effects, etc., but at the same time eliminate, by displaying an area of mildly illuminated glassware, the impression of "flatness" apt to be associated with an apparent absence of any visible source of light. From the aesthetic standpoint, however, some objection has been taken to the design previously adopted, by reason of the prominence of the tubular supporting arms. In the new model these are eliminated and replaced by a shallow dish of pleasing contour. The improved appearance of the fitting has, we understand, already enhanced its popularity and led to its selection for use in certain public buildings.



IN NEXT NUMBER
(November, 1934)—

we shall complete the reproduction of the papers read at the Eleventh Annual Meeting and Conference of the Association of Public Lighting Engineers in Aberdeen, give some account of the Discussion, and also a fuller description of the Exhibition of Public Lamps and Lighting Appliances.

"LUX"
(La Revue de l' Eclairage)

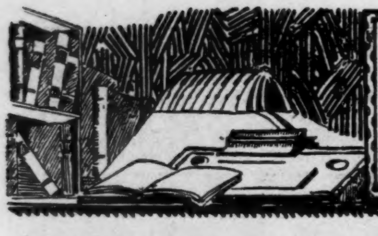
WE have pleasure in announcing to our readers that we have entered into an arrangement to receive subscriptions for the French Journal "Lux" (La Revue de l' Eclairage). The subscription per annum is 30 francs, the approximate equivalent of which in English money is Seven Shillings and Six Pence (7/6).

"Lux" is the only French journal which specialises in all aspects of lighting, it is the official organ of the Association Francaise des Ingenieurs de l' Eclairage (equivalent to the Illuminating Engineering Society in France).

It furnishes a complete record of interesting developments in lighting in France and on the Continent. It is fully illustrated and in particular devotes a considerable number of its pages to Decorative Lighting.

By studying these articles and the numerous photographic reproductions of modern lighting installations the reader can readily gain an excellent impression of French methods and practice in matters of Illumination.

Applications for subscriptions will be received by "The Illuminating Engineer," 32, Victoria Street, London, S.W.1.



REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED

Neon Tube Practice.

W. L. Schallreuter, Dr. Phil., 132 pp. (*Blandford Press*, 1933.)

The author gives a brief outline of the theory, manufacture, and use of discharge tubes for advertising purposes. No attempt has been made to write a complete work on the subject, and the book is therefore not for the highly technical expert, but it should be useful to those others who are interested in or associated with "Neon" lighting; it starts from zero, introduces the subject in simple language, and gives a good general idea of how tubes are made and what are the difficulties encountered in practice and of those still confronting the industry.

The manufacture of Neon signs is a highly technical and skilled process; there is much unexplored ground and many pitfalls Consequently, their production is probably best and indeed is likely to remain mainly in the hands of those manufacturers who can shoulder the cost of progress in a young industry; but there are many, salesmen and others, who have to "talk" signs, and these will welcome a better understanding of some of the mysteries of Neon tubes. The departure from Ohm's law, "hardening," "splashing," the rare gases, cleaning up, striking and running potentials and "leaky" transformers; these will be understood well enough for all sales purposes, whilst the reader may also study those matters more directly affecting the purchaser—for example, gas mixtures, absorbing glasses and their resultant colours, tube distribution and sizes, backgrounds and their colouring, safety regulations, and power factor correction.

Other subjects of interest which are dealt with are low voltage Neon, hot cathodes, ageing of tubes. "wriggle" tubes, and medical applications.

The book is illustrated and the plates of actual installations are well done. It is a useful addition in a field where such information has been wanting.

The Power Factor Booklet.

R. Amberton, M.I.E.E. 82 pp. (*Electrical Apparatus Co., Ltd., London*, 1934.)

The first edition of this little work was published in 1924 and consisted mainly of a series of analogies of power factor. In this new edition the scope has been extended to include a simple exposition of such electrical terms and functions as are necessary in order to enable the average man of affairs to get some insight into the considerations governing electricity supply. The book falls into four main sections. Section A deals in a simple manner with electrical terms and measurements, Section B with commercial aspects (e.g., the basis of tariffs) and with the power factor, which is again explained by a series of analogies contributed by various authors. Section C is devoted to power factor correction, and Section D (which is intended for the technical reader) with new technical developments. The simple treatment seems likely to appeal to members of parliamentary and municipal committees, industrialists, and students, for whom, it is stated in the preface, the book is mainly intended.

Automatic Street Signalling.

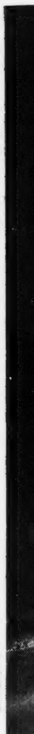
H. H. Harrison and T. P. Priest, 187 pp. (*Sir Isaac Pitman and Sons, London*, 1934.)

This book, which is furnished with a foreword by Sir Henry Maybury, deals with a subject of great interest to traffic authorities, and incidentally to public lighting engineers. Automatic signalling systems have developed with singular rapidity during recent years. As Sir Henry Maybury remarks, the vehicle-operated system is of special interest in view of its value in relieving congestion and avoiding the necessity for costly widening of streets. The authors have prepared a complete analysis of the subject. Chapter I., of an introductory nature, is in some ways the most interesting. The drawbacks of manual control are stated, and the evolution of mechanical signalling for street traffic is sketched out. Methods of dealing with various types of traffic problems and the successive developments of synchronous limited progressive and flexible progressive control are illustrated by numerous diagrams. Chapters II. and III. are concerned with controller mechanisms and signal and controller mountings. Chapter IV., dealing with the theory of traffic movement, is of a somewhat intricate nature, but should well repay study by the traffic expert. The final chapters deal with vehicle-operated systems and their application to traffic control. The paper and printing are good, and there is an adequate index. The authors have rightly appreciated the fact that this is a subject which can only be elucidated by a liberal use of diagrams, and the numerous illustrations—approximately 150 in 180 pages—are exceptionally clear and well executed.

Load Building With Light.

(*E.L.M.A. Lighting Service Bureau*, 1934.)

We take this somewhat belated opportunity to refer to the above ingenious booklet, summarising some of the data presented at the I.M.E.A. Convention. The get-up is excellent and the various diagrams illustrating consumption of electricity for domestic, shop, and industrial uses, show how very far from satisfied is the potential demand. Supply undertakings, who have been somewhat prone to concentrate on power and heating demands, should revise their ideas on the value of the lighting load, which is not only well worth having, but well worth developing also. Of special interest are the "Points for the Lighting Salesmen," issued as an inset to the brochure. "It takes three times as much light to read a newspaper with the same ease as it does a well-printed book"; "An object must be twice as large to be as visible under 1 foot-candle as it would have to be under 100 foot-candles"; "You can light a bridge party for bedroom effectively for six months for the cost of a small bottle of scent." These are statements which "give furiously to think," do they not?



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